GE Fanuc Automation

CIMPLICITY® Monitoring and Control Products

CIMPLICITY

Statistical Process Control

Operation Manual

GFK-1413E *December 2000*

Following is a list of documentation icons:

Warning notices are used to emphasize that hazardous voltages, currents, temperatures, or other conditions that could cause personal injury exist in the equipment or may be associated with its use.

Caution provides information when careful attention must be taken in order to avoid damaging results.

Important flags important information.

To do calls attention to a procedure.

Note calls attention to information that is especially significant to understanding and operating the equipment or software.

Tip provides a suggestion.

Guide provides additional directions for selected topics.

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Preface

Content of this Manual

This manual is composed of the sections described below.

Chapter 1. Introducing Statistic Process Control: Describes the SPC features.

Chapter 2. SPC Overview: Describes how SPC operates, provides illustrations of the chart types and suggested reading for additional information on statistical process control.

Chapter 3. SPC Data Source Overview: Discusses the SPC data source and its configuration.

Chapter 4. Configuring SPC Data: Provides instruction on configuring SPC data using abundant graphics to enhance the procedures.

Chapter 5. Configuring SPC Charts: Describes the available options for creating SPC ActiveX controls.

Chapter 6. Using SPC Charts: Describes the runtime options for SPC ActiveX controls.

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Related Publications

For more information about CIMPLICITY HMI software, refer to these publications:

CIMPLICITY Base System User's Manual (GFK-1180)

CIMPLICITY CimEdit Operation Manual (GFK-1396)

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Glossary of Terms

Attribute Data

The qualitative data that can be counted for recording and analysis. Attribute data is usually gathered in the form of nonconforming units. The units are analyzed by P, nP, C and U control charts.

Attribute Quality Characteristic

A distinguishing feature of a process or its output on which attribute data can be collected.

Average

The sum of values divided by the number, or sample size, of values. This is usually designated by a bar over the symbol for the values being averaged. The most common averages in SPC are:

$\overline{X}$ The average of values within a subgroup.

$\overline{\overline{X}}$ The average of subgroup averages (also called the process average)

$\overline{R}$ The average of subgroup ranges.

Central Line

The line on the control chart that represents the average value of the items being plotted.

Characteristic

A distinguishing feature of a process on which variable data can be collected.

Control Chart

A graphic representation of a characteristic of a process. It shows the plotted values of data for the characteristic, a central line and one or two control limits.

Control Limit

A line, or lines, on a control chart used as a basis for judging the stability of a process. Control limits are calculated from process data.

Defect Data

Defect data consists of a defect code and a count of the number of units that contain that defect. It is possible for a unit to contain more than one defect. Defect data is displayed in a Pareto chart which ranks the defects by number of occurrences.

Defect Quality Characteristic

For CIMPLICITY SPC, a Defect Quality Characteristic defines the collection of defect categories be used for defect data for a Pareto chart. Other terms for Defect Quality Characteristic are Defect QC or defect data.

Document

For CIMPLICITY SPC, a document is a collection of products for which you are going to collect and analyze variable quality characteristics and defect data.

Mean

See Average.

Median

The middle value of a group of measurements when they are arranged in order from lowest to highest. The median is *not* an average.

Observation

An observation is a single instance of data.

Pareto Chart

A chart that ranks all potential problem areas according to their contribution to the total variation. Typically, a few causes account for most of the variation. In CIMPLICITY SPC, the contents of a Defects folder contain the data displayed in a Pareto chart.

Process Capability

The total range of a stable process's inherent variation. For variable data:

The process's inherent capability is defined as $6\hat{\sigma}_{\bar{R}/d_2}$

The capability index for a stable process is C_{PK}

Process Spread

The extent to which the distribution of individual values of the process characteristic vary. This is often shown as the process average plus or minus some number of standard deviations. For example: $\overline{\overline{X}} \pm 3\sigma$

Product

For CIMPLICITY SPC, a product is the entity for which you want to collect Variable quality characteristics or Defect data for analysis

Range

The difference between the lowest and highest values in a subgroup.

Run

A consecutive number of points consistently increasing or decreasing or above or below the central line.

Sigma

The Greek letter - σ - used to designate a standard deviation.

Special Cause

A source of variation that is intermittent and often unpredictable. Sometimes called an assignable cause, it is signaled by a point beyond the control limits, a run, or other non-random pattern of points within the control limits.

Standard Deviation

A measure of the spread of the process output.

Subgroup

A subgroup is a set of one or more observations that are used to calculate a point on an SPC chart. Another term for a subgroup is a sample.

Variable Data

Variable data consists of measurable parameters such as weight, temperature, or length.

Variable Quality Characteristic

For CIMPLICITY SPC a Variable Quality Characteristic is a measurable parameter such as weight, temperature or length. Other terms for Variable Quality Characteristic are Variable QC or variable data.

Introducing Statistical Process Control

Welcome to Statistical Process Control

Welcome to Statistical Process Control (SPC), CIMPLICITY's state-of-the-art option for supporting a successful quality control program! SPC enhances your ability to manage a quality control program by addressing the four major phases of quality control:

- Measurement
- Analysis
- Improvement
- Control

CIMPLICITY SPC supports your quality control program by enabling you to:

- collect substantial amounts of accurate data.
- convert data into meaningful information.
- use information to change your process and increase quality.
- monitor your process on a continuous basis.
- react to runtime information.
- maintain consistent quality levels.

SPC is built on and fully integrated with the CIMPLICITY® HMI family of products. As with all CIMPLICITY products, SPC runs in a Windows-based environment enabling flexibility for multiple users and a familiar platform that decreases the learning curve.

About the CIMPLICITY HMI SPC Option

The CIMPLICITY HMI SPC option provides you with the industry-standard set of statistical tools that enable you to analyze data and convert it into useful information. CIMPLICITY HMI SPC is capable of collecting and analyzing data 24-hours a day, providing critical information about potential quality problems using the alarming feature. This enables you to make improvements to your quality program, and allows you to monitor changes and verify results.

CIMPLICITY HMI SPC provides you with the following types of charts and printed reports for analyzing your process data:

Variable Characteristics	**Attribute Characteristics**	**Defects**
Bar R	p	Pareto
XBar S	nP	
X Individual	c	
Histogram	u	

Based on Microsoft's design standards, CIMPLICITY SPC charts are designed as OCX control objects, so that they are easily added to your CimView screens.

Note: This manual is not intended to provide instruction on CIMPLICITY HMI or your Windows operating system, and it is assumed that users have a working knowledge of both software products. Please refer to the documentation that originally came with your software for questions about CIMPLICITY and Microsoft Windows.

SPC Features

The SPC option comes complete with a host of exciting features.

Major features include:

- Live data viewing from ActiveX containers such as CimView screens and Internet Explorer.
- Easy scalability from a simple workstation to Client-Server configurations.
- Generation of CIMPLICITY HMI alarms for out-of-control conditions. This means in addition to displaying out-of-control conditions on SPC charts, you can display alarms for them in the Alarm Viewer, log them to an Alarm Log Printer, and log them via the Database Logger.
- Centralized configuration that allows for the creation and maintenance of all the various characteristics and specification limits for your process, even though your charts may cross over several CimView screens on your HMI system.
- XBar-R, X-Individual, XBar-S, and Histogram charts for variable quality characteristics.
- p, nP, c and u charts for attribute quality characteristics.
- Pareto charts for defect analysis.
- Tabular reports that let you view numeric data in table format.
- High quality printing directly from the SPC ActiveX control.
- Both logged and runtime Point data collection.
- Access to changing values for sample sizes, control limits and auto recalculation during runtime.
- Manual data entry through a dialog in the SPC ActiveX control.
- Calculated data stored in a database via ODBC that lets you use standard database tools for such things as exporting data, reporting and maintenance.

SPC Components

The SPC option consists of the following three components:

- **SPC Data Collector**: Process that runs in the background and collects data, performs analysis, alarms out-of-control conditions and writes calculated data to the database based on your configuration. A new enhanced feature of SPC is the ability to analyze attribute data and store the resulting data in a database for further processing.
- **SPC Group Configuration**: Graphical User Interface that enables you to configure the quality characteristics and defect categories to be analyzed. The latest addition to the Interface is the ability to configure attribute characteristics.
- **SPC ActiveX Control**: ActiveX control that can be embedded in an ActiveX container, such as a CimEdit/CimView screen or Internet Explorer. This enables you to view the data analyzed by the SPC Data Collector through various charts and reports. Also, you can perform such functions as manually entering data, printing, displaying charts, and setting up an ODBC data source.

Upgrade Old SPC Charts

You will be required to upgrade your existing SPC charts if they meet one of the following conditions:

- The charts were created *prior* to CIMPLICITY HMI v3.1
- The charts were created using CIMPLICITY HMI v3.1, but you did not purchase and install the Enhanced SPC software (IC646NSP000A) prior to making them.

Note: When attempting to view a screen containing an old SPC chart, an error message will display indicating that the charts must be upgraded.

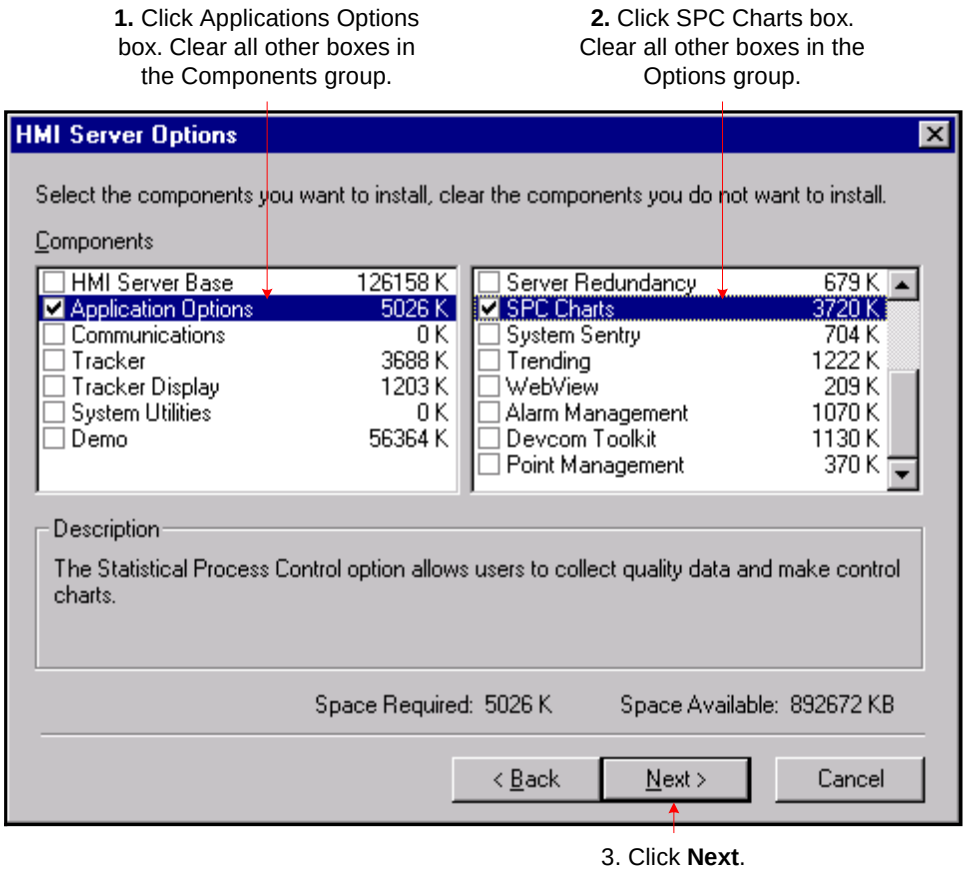
See "Upgrading Quality Charts to Enhanced SPC Charts" for information on upgrading SPC charts.

Quick Start: Install and Configure the SPC Option

Before you can begin to use the powerful features offered by the SPC option, make sure the option is installed on all computers where you want to collect or view SPC data. Installing the SPC option is quick and easy using your original installation CD for CIMPLICITY HMI.

To install the SPC option:

1. Place the installation CD in the CD-ROM drive.
2. The CD will AutoPlay—***OR***—from the Windows desktop, press Start>Run. Type **d:\setup.bat** (where **d** is the CD-ROM drive) and click **OK**.
3. Select Install CIMPLICITY HMI from the menu.
4. Proceed to the CIMPLICITY HMI Setup dialog box.
5. Click the Review/Add Options radio button.
6. Click **Next** to display the HMI Server Options dialog box—see figure.


1. Click Applications Options box. Clear all other boxes in the Components group.
2. Click SPC Charts box. Clear all other boxes in the Options group.
HMI Server Options
Select the components you want to install, clear the components you do not want to install.
Components
HMI Server Base 126158 K
Application Options 5026 K
Communications 0 K
Tracker 3688 K
Tracker Display 1203 K
System Utilities 0 K
Demo 56364 K
Server Redundancy 679 K
SPC Charts 3720 K
System Sentry 704 K
Trending 1222 K
WebView 209 K
Alarm Management 1070 K
Devcom Toolkit 1130 K
Point Management 370 K
Description
The Statistical Process Control option allows users to collect quality data and make control charts.
Space Required: 5026 K
Space Available: 892672 KB
< Back
Next >
Cancel
3. Click Next.

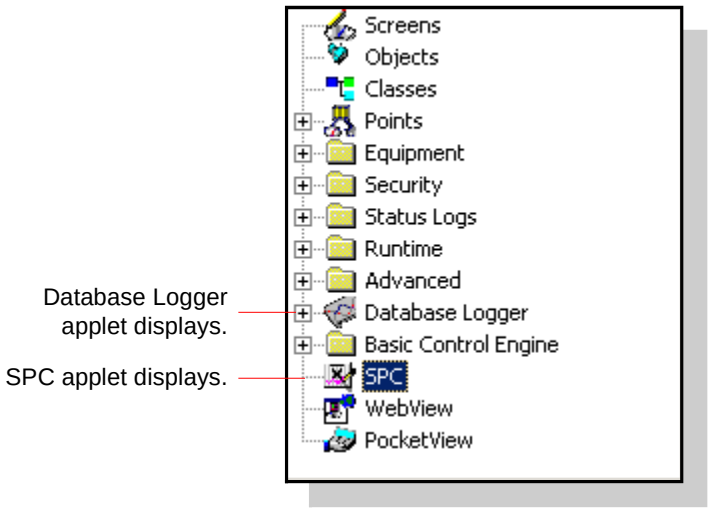
7. Check the Application Options box.
8. Check the SPC Charts box.
9. Clear all other boxes in the Components group.

10. Click **Next** to proceed with installation.
11. Restart your computer once the SPC option has been installed.

To configure SPC:

1. Configure an ODBC data source. A default Microsoft Access database called **CIMPLICITY SPC** is automatically created when you install SPC. You only need to change or reconfigure this if you want to use a data source other than Microsoft Access.
2. Configure SPC data collection as follows:
   a. Open your project in the Workbench.
   b. Click Project on the menu bar.
   c. Select Properties to open the Project Properties dialog box.
   d. Check the SPC Charts and Database Logger boxes in the Options group.
   e. Click **OK**.

Result: The Database Logger and SPC applets display in the project directory—see figure.



   f. Double-click the SPC applet and configure an SPC document. *For complete instructions, see "Configuring SPC Data."*
3. Run your project.

Result: SPC data collection automatically starts.

4. Configure an SPC chart(s). *For complete instructions see, "Configuring SPC Charts."*

   a. Insert the CIMPLICITY SPC Control in an ActiveX container, such as a CimEdit screen or Internet Explorer.

   b. Edit the chart properties; click the General tab and do the following:

      - Browse for and select the SPC document.
      - Select the product to be displayed.
      - Select one of the configured QCs (variable, attribute or defect) for the product.
      - Select the chart type for the display.
      - Select the chart duration.

   c. Click the Chart tab and do the following:

      - Select the type of chart to be displayed.
      - If you selected Show most recent values on the General tab, enter the update interval.

Note: Other chart properties are configured for your convenience. You may use these default properties or tailor them to your application.

SPC Overview

SPC Analysis

SPC uses statistical methods to determine whether processes are within required limits. While CIMPLICITY HMI's normal alarm functions detect when individual Points actually exceed limits, SPC analysis can provide early warning by detecting undesirable systematic variations in your process. This can help you pinpoint process, machine, operator, or material problems so that actions can be taken to diagnose and resolve the problem.

CIMPLICITY SPC uses an SPC ActiveX control that supports:

- XBar-R, XBar-S, X-Individual and Histogram charts for analyzing variable data.
- p, nP, c, and u charts for analyzing attribute data.
- Pareto charts for analyzing defect data.

The data is retrieved from ODBC logging, analyzed according to the standard SPC calculations for the chart, and displayed graphically by populating configured charts with the result. This ActiveX control can be used in CimEdit/CimView screens or other applications, like Internet Explorer that supports ActiveX controls.

The SPC variable charts display values between -4 sigma (-4σ) and +4 sigma (+4σ). Data outside of this range is not displayed, but it *is* still used in the chart calculations.

Suggested Readings

This manual shows you how to use the SPC option available for CIMPLICITY HMI. To acquire additional information about SPC, please consult one of the many SPC publications that are currently available.

Suggested publications are:

- *Easy as SPC*, Perry Johnson, Inc., 1986
- *Statistical Quality Control Handbook*, Western Electric Co., Inc., 1959
- *Quality Control and Industrial Statistics*, Charbonneau and Webster, 1978
- *Introduction to Statistical Quality Control*, Montgomery, 1985
- *Statistical Process Control*, Chrysler Corporation, Ford Motor Company and General Motors Corporation, 1995

Professional groups that publish manuals and booklets about SPC are the:

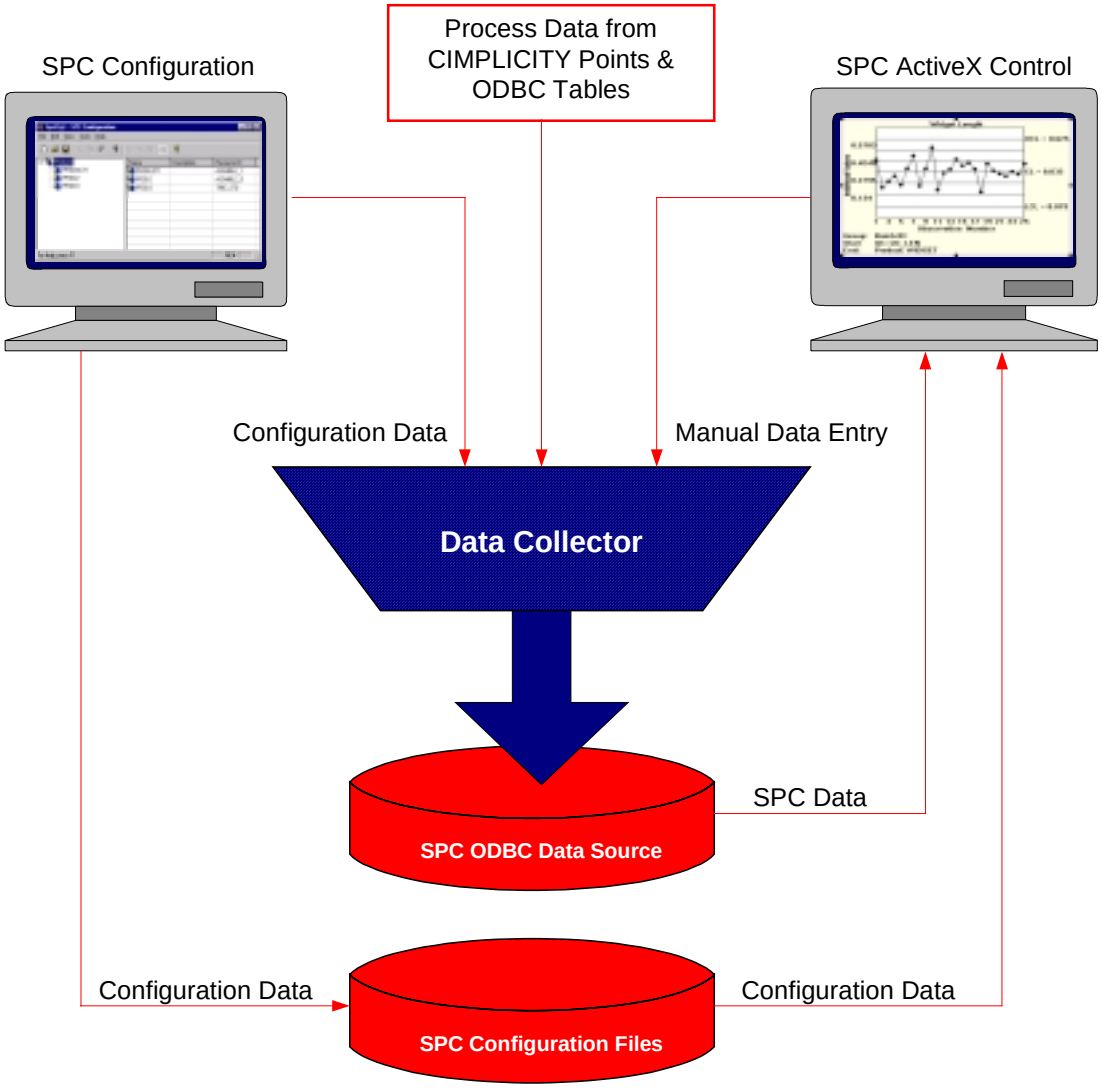
- American National Standards Institute
- American Society for Quality Control
- American Society for Testing and Materials

SPC Operation Overview

CIMPLICITY HMI performs a series of functions in order to provide you with information through the SPC option.

The following process supports SPC—see figure:

- SPC Configuration tells the Data Collector how and from where to collect the data.
- The Data Collector gathers CIMPLICITY Point, ODBC and manual entry data, performs its required calculations and stores the results in the SPC ODBC data source.
- The SPC ActiveX control displays the data from the SPC ODBC data source. It can also send manual entry data back to the Data Collector for processing.



SPC Chart types

You can use the SPC ActiveX control to display charts for variable, attribute or defect data. Data can also be displayed in report format.

The SPC ActiveX Control can display the following types of charts and reports:

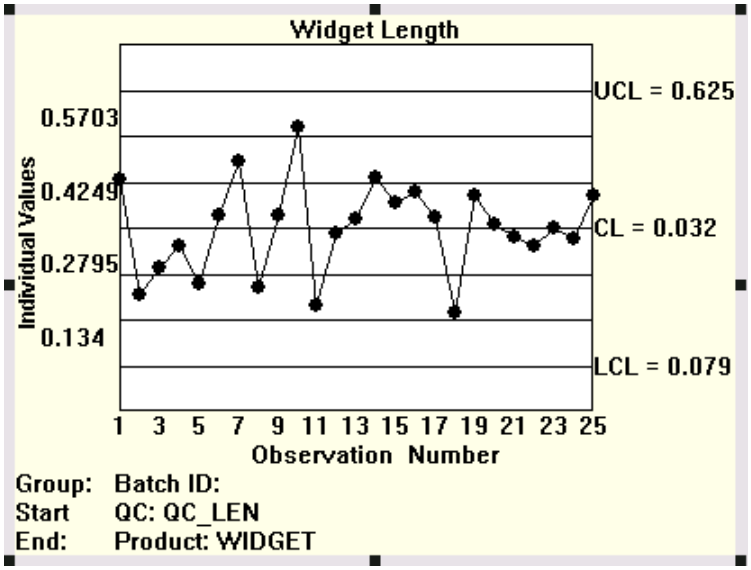
Variable Data	Attribute Data	Defect Data	Reports
▪ X-Individual chart	▪ p chart	▪ Pareto chart	▪ Sample Report
▪ XBar-R chart	▪ nP chart		
▪ XBar-S chart	▪ c chart		
▪ Histogram	▪ u chart		

In general, a control chart consists of a center line corresponding to the average value at which the quality characteristic should perform, and lines corresponding to the upper and lower control limits for the characteristic. The upper and lower control limits are also referred to as the upper and lower three-sigma control limits.

X-Individual Chart

The X-Individual chart is sometimes called a pre-control chart. This type of chart is used to determine the stability of the center of the process. The control limits are calculated by determining the standard deviation of the sample population. The formulas for calculating the standard deviation and control limits are detailed in Appendix B.

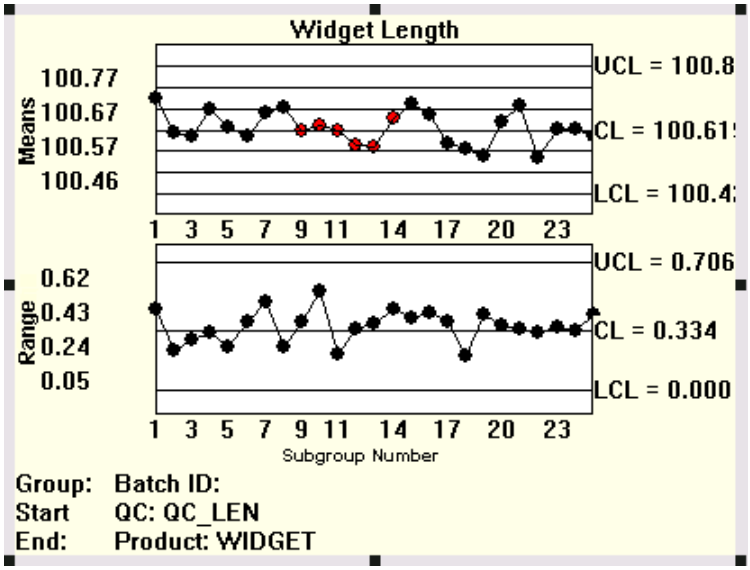
The following is an example of an X-Individual chart that was created using SPC ActiveX Control:



XBar-R Chart

The XBar-R chart displays two charts, one for the XBar values and the other for the Range values. The formulas for calculating the center lines and control limits for the XBar-R control chart are detailed in Appendix C.

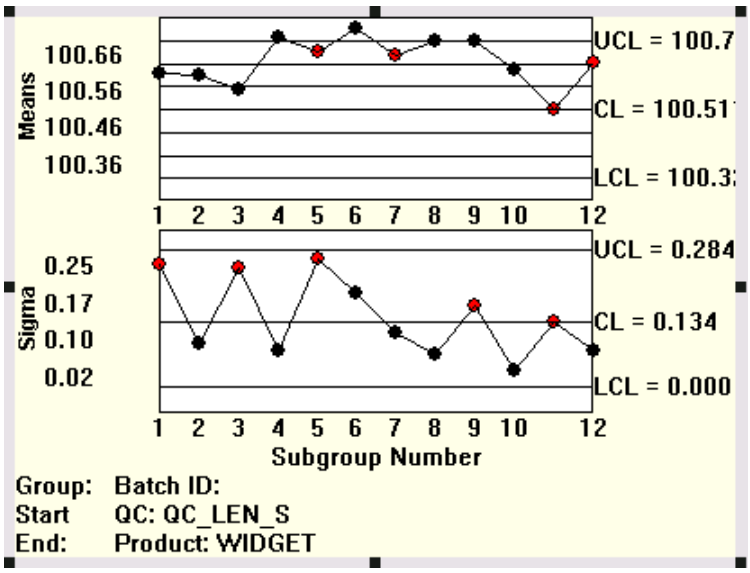
The following is an example of an XBar-R chart created using SPC ActiveX Control:



XBar-S Chart

The XBar-S chart displays two charts, one for the XBar values and the other for the Sigma values. The formulas for calculating the center lines and control limits for the XBar-S control chart are detailed in Appendix D.

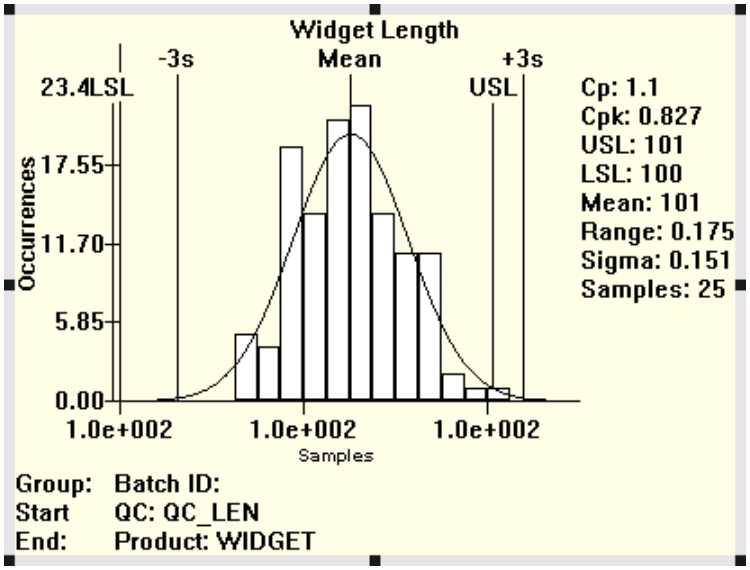
The following is an example of an XBar-S chart created using SPC ActiveX Control:



Histogram

The Histogram shows you the distribution, the central tendency and the scatter or variability of the sample data, and calculates process capability. The formulas for calculating process capability from the Histogram chart are detailed in Appendix E.

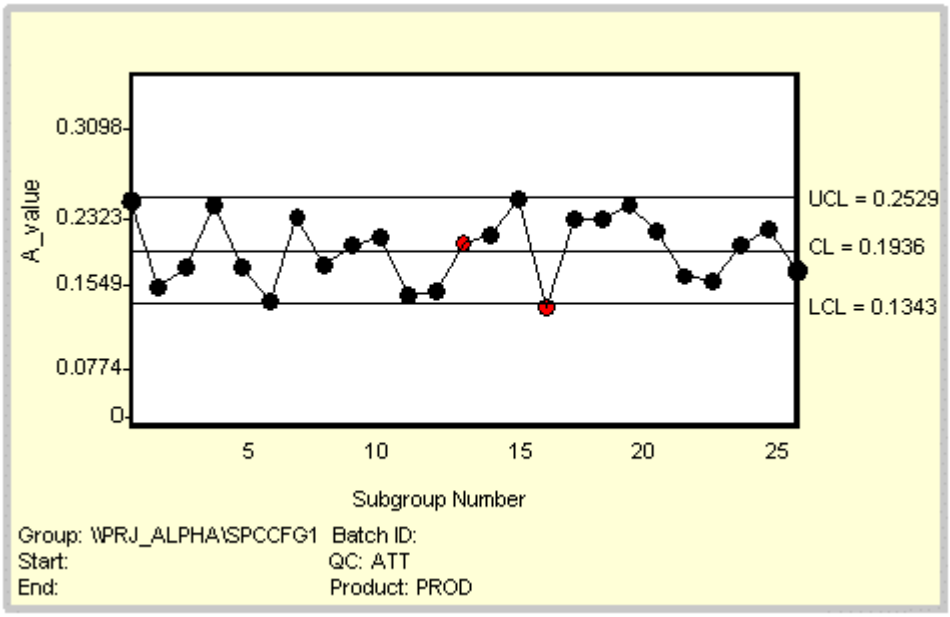
The following is an example of a Histogram created using SPC ActiveX Control:



P Chart

The P chart measures the proportion of nonconforming (discrepant or defective) items in a group of items being inspected. Proportion is defined as the ratio of the number of nonconforming items in a population to the total number of items in that population. Sample sizes do not have to be equal.

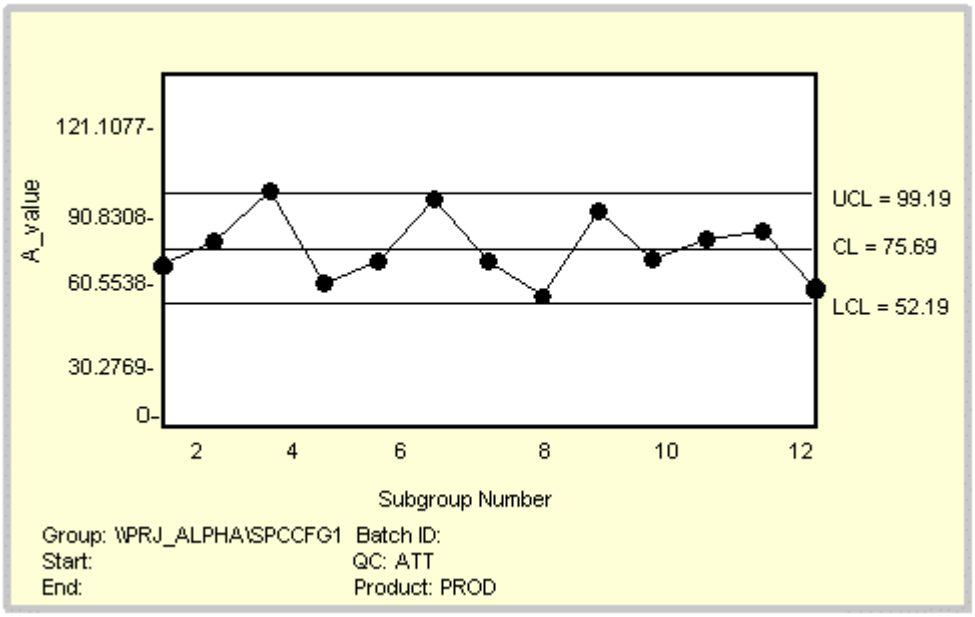
The following is an example of a P chart created using SPC ActiveX Control:



nP Chart

The nP chart measures the number of nonconforming items in an inspection lot. It is identical to p chart except that the actual number of nonconforming items is plotted, rather than their proportion of the sample. The inspection sample sizes must be equal in this case.

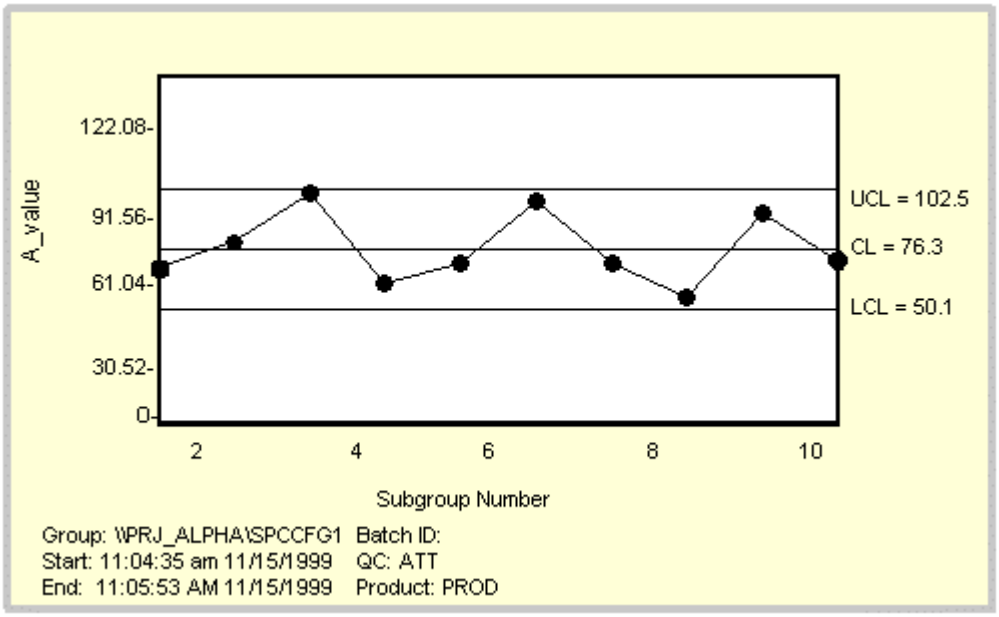
The following is an example of an nP chart created using SPC ActiveX Control:



C Chart

The C chart measures the number of nonconforming items (discrepancies or defects) in an inspection lot. The C chart requires a constant sample size.

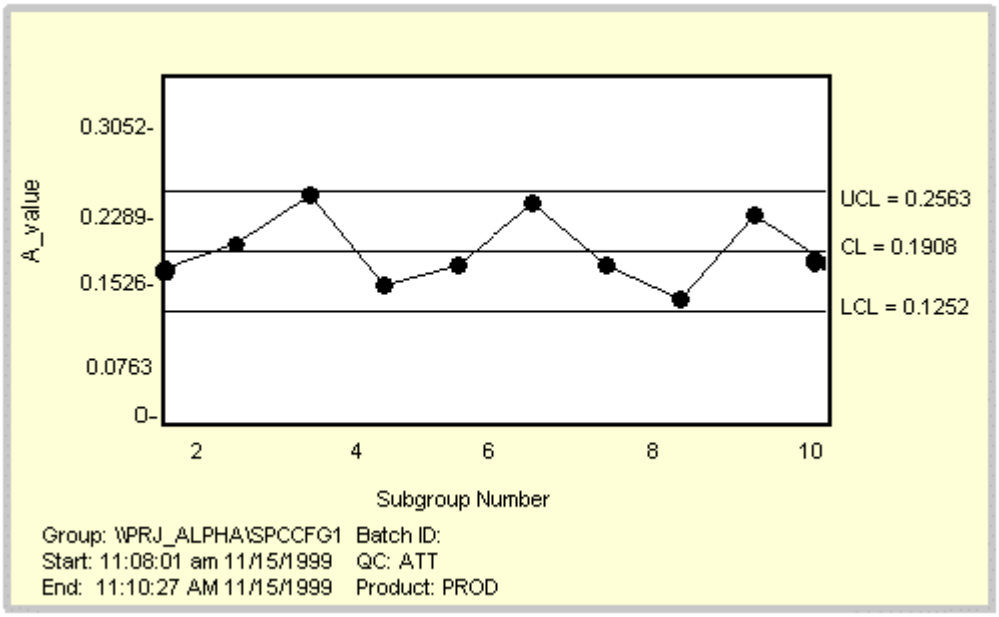
The following is an example of a C chart created using SPC ActiveX Control:



U Chart

The U chart measures the number of nonconforming items per inspection unit in subgroups, which can have varying sample sizes. It is similar to C chart except that the number of nonconforming items is expressed on a per unit basis.

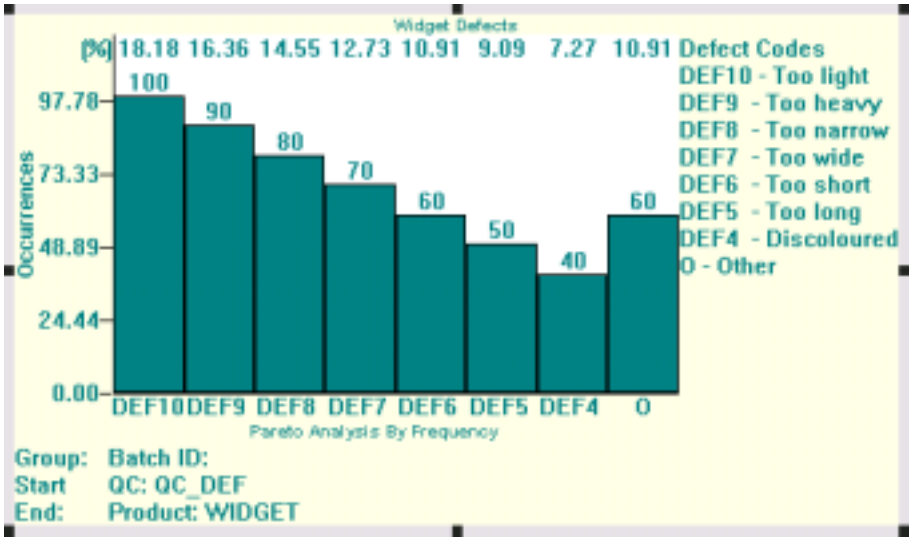
The following is an example of a C chart created using SPC ActiveX Control:



Pareto Charts

The Pareto chart displays the data for the defect categories and quantities you define for a defect folder.

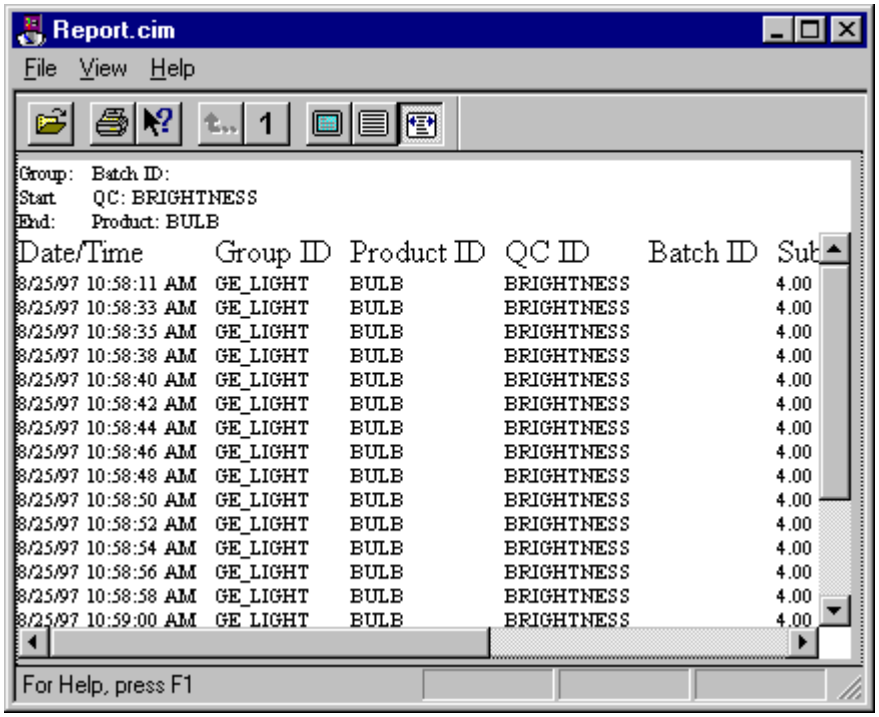
The following is an example of a Pareto chart created using SPC ActiveX Control:



Reports

You can display and print data from the SPC ActiveX control for each type of SPC chart.

The following is an example of a report created using SPC ActiveX Control:


Report.cim
File View Help
Group: Batch ID:
Start QC: BRIGHTNESS
End: Product: BULB
Date/Time Group ID Product ID QC ID Batch ID Sub
8/25/97 10:58:11 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:58:33 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:58:35 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:58:38 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:58:40 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:58:42 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:58:44 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:58:46 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:58:48 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:58:50 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:58:52 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:58:54 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:58:56 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:58:58 AM GE_LIGHT BULB BRIGHTNESS 4.00
8/25/97 10:59:00 AM GE_LIGHT BULB BRIGHTNESS 4.00
For Help, press F1

SPC Data Source Overview

SPC Data Source

SPC automatically creates a default Microsoft Access data source for you called CIMPLICITY SPC. New SPC documents will use this data source by default. You have the option of creating your own data source using another database such as SQL Server or Oracle, if you want better performance or if you want to share the same data source across a network.

All the SPC documents in a CIMPLICITY HMI project must log their data to the same SPC data source. You can share an SPC data source between projects, or you can create a data source for each project.

See the CIMPLICITY HMI Base System User's Manual, GFK-1180, for detailed instructions on creating custom data sources for Microsoft Access, SQL Server and Oracle.

Note: The SPC data source ***must*** be a System data source.

Configuring SPC Data

Introduction

SPC offers several data collection types, including using Points to track the quality of variables and attributes, and the frequency of defects. You can also implement several types of control tests, the results of which can be displayed on XBar-R or XBar-S chart sets for variables, and p, nP, c and u chart sets for attributes.

With this in mind, begin configuring your SPC application(s) considering which factors will be needed to support your quality control program.

Consider the following:

- Who will use SPC and in what manner. Configure SPC for users who:

  will have SPC on a server and will be able to configure SPC data.

  will have a runtime version and will make runtime decisions.

- What products SPC will be tracking for data.
- Which variables are to be monitored for quality, for example Widget_length. In order to keep data management under control, begin with a few of the most critical variables. This will prevent you from becoming overwhelmed by too much information. Also, avoid collecting data too frequently.
- Which attributes require monitoring for quality. Again, select only the most critical attributes when you first begin.
- Which defects for each product need to be tracked, for example Color_too_light.

Important: The SPC Data Collector logs its raw and calculated data to an ODBC data source. Before you start configuring SPC for a project, make sure that the CIMPLICITY Database Logger is installed and configured for the project.

Overview of Data Configuration Steps

In order to configure SPC to collect, analyze and display statistical data, follow the steps outlined below. Detailed procedures for each for each of the steps are provided in this chapter.

Step One. Add and Configure an SPC Document

The SPC document is the container for all of the products that are to be grouped together. The products' variables, attributes and defects are stored here in a directory structure similar to Windows Explorer.

The properties that you specify for your document will impact all of its included products. For example, the designated ODBC data source will store data calculated from the SPC Data Collector for all the products included in the document.

Step Two. Add and Configure Products

The product is the main container for the type of data that you will choose to collect and analyze. Initially you will provide a name, description and resource ID for your product.

Step Three. Add and Configure Variable Quality Characteristics

Specify the variables you want to measure for each product. For each variable, indicate the following information:

- Description (for example, Widget_Length)
- Collection characteristics
- Limits
- Alarms
- Calculation Type

For each variable that you add, a histogram is automatically generated by SPC. In addition you can select between the following chart types:

- XBar-R chart set to view the range between the highest and lowest point in a sample. This range is relatively efficient for small subgroup sample sizes (especially below 9). Although it provides you with a spread, it does not give you a clear indication of where the points fall relative to your control limits.
- XBar-S chart sets to review the average of the standard deviations.
  This is a more efficient indicator of process variability, especially with larger sample sizes. However, it is less sensitive in detecting special causes of variation that result in only a single value in a subgroup to be unusual.

  From *"Statistical Process Control,"* Chrysler Corporation, Ford Motor Company and General Motors Corporation, 1995

Step Four. Add and Configure Attribute Quality Characteristics

Specify the attributes you want to measure for each product. For each attribute, indicate the following information:

- Description (for example Color_Light)
- Collection characteristics
- Limits
- Alarms
- Calculation Type

In addition you can select from among the following chart types:

- p chart set measures the proportion of nonconforming (discrepant or defective) items in a group of units being inspected. Proportion is defined as the ratio of the number of nonconforming items in a population to the total number of units in that population. Sample sizes need not be equal.
- nP chart set measures the number of nonconforming units in an inspection lot. It is identical to p chart, except that the actual number of nonconforming units, rather than their proportion of the sample are plotted. The inspection sample sizes must be equal in this case.
- c chart measures the number of nonconforming units (discrepancies or defects) in an inspection lot. The c chart requires a constant sample size.
- u chart measures the number of nonconforming items per inspection unit subgroups, which can have varying sample sizes. It is similar to c chart, except that the number of nonconforming units is expressed on a per unit basis.

Step Five. Add and Configure Defect Categories

Specify the defects that are to be tracked for each product. For each defect, indicate the following information:

- Defect Description
- Scope (for example, if you want to use the same data source for multiple defects)
- Collection characteristics
- Measurement—SPC generates Pareto charts by default

Note: If you already know the control limits for a process, simply enter them. If not, for example because the process is new, use SPC auto recalculation to calculate control limits for variables and attributes. When you are satisfied with the calculated limits, enter the calculated limits and disable SPC auto recalculation.

SPC Document

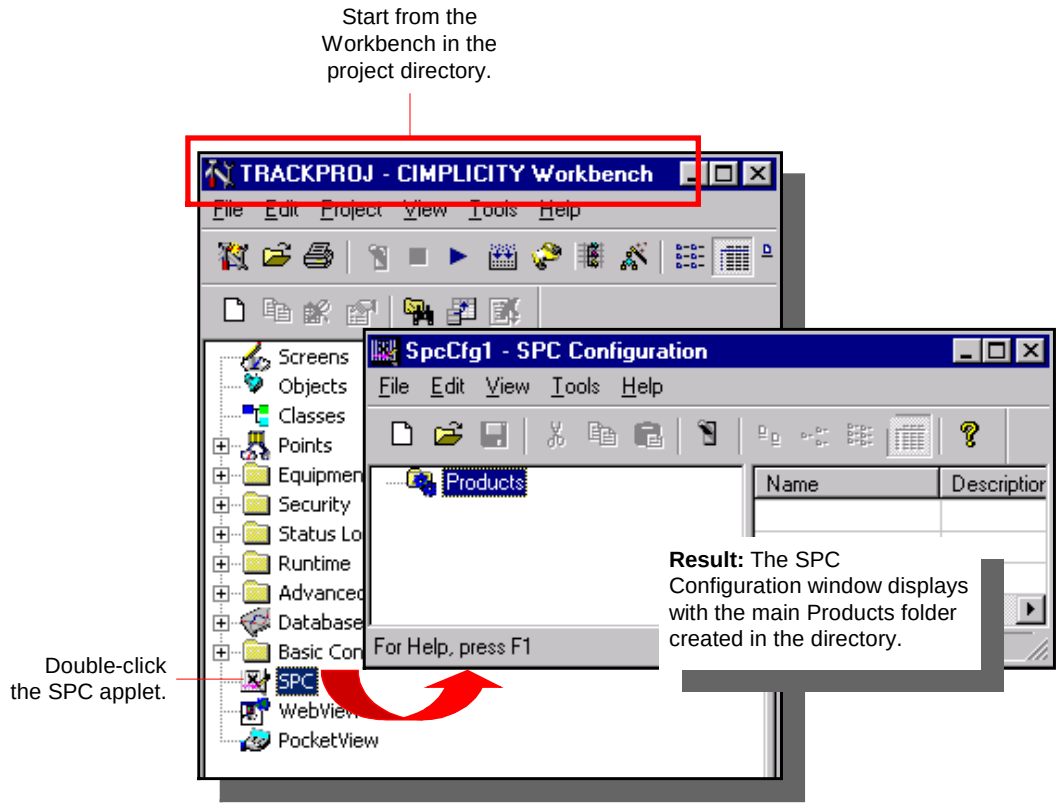
Software configuration for SPC begins with opening and configuring an SPC document. The SPC document is the container for one or more products that you will add and configure. When the document is active, every included product will be tracked, unless you deactivate tracking for one or more of the products at the product level. *See "Defining Product Properties."*

Opening a New Document

To open an SPC document:

1. Open your project in the Workbench.
2. Double-click on the SPC Configuration applet in the project directory.

Result: The first time you double-click the SPC Configuration applet, a new document will open with one Products folder displayed in the directory. All related products, and their accompanying variables, attributes and defects will be placed in this main Products folder—see figure.

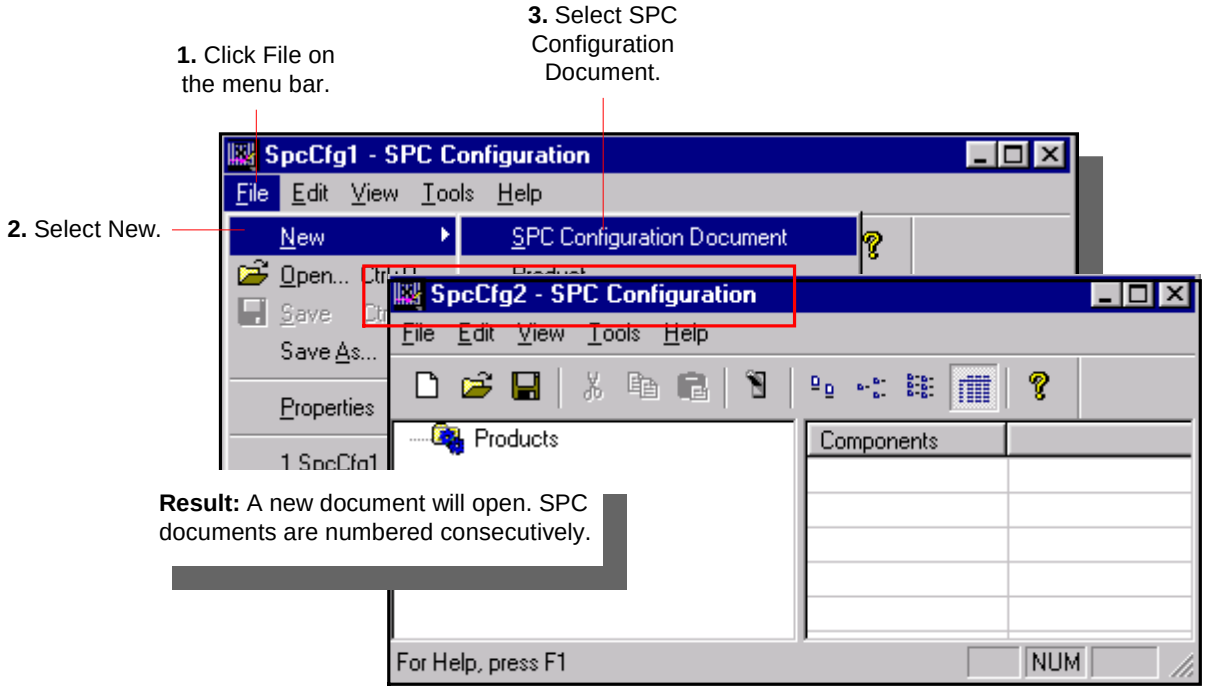


Note: More than one document can exist in a project.

To create additional documents:

1. Click File on the menu bar.
2. Select New.
3. Select SPC Configuration Document from the pullout menu.

Result: A new SPC configuration window will display. SPC documents are numbered consecutively—see figure.



Important: You must use the same data source for all SPC documents created in a project.

To build directory hierarchy:

As you build your configuration, you add a hierarchy of subfolders to the Products main folder, as follows:

1. Within the Products main folder, a subfolder for each product included in the document.
2. Within each Product subfolder are the following:
   - **Variable QC** item for each variable that will be tracked for that product and displayed on an XBar-R or XBar-S chart.
   - **Attribute QC** item for each attribute that will be tracked for that product and display on an p, nP, c or u chart.

- **Defect** folder for each group of defects that will be tracked for a product and displayed on one Pareto chart. Included are all the defect categories that will be displayed as a bar on the group's Pareto chart.

Defining Document Properties

The SPC document is the primary container for your quality control information. You can set its properties to:

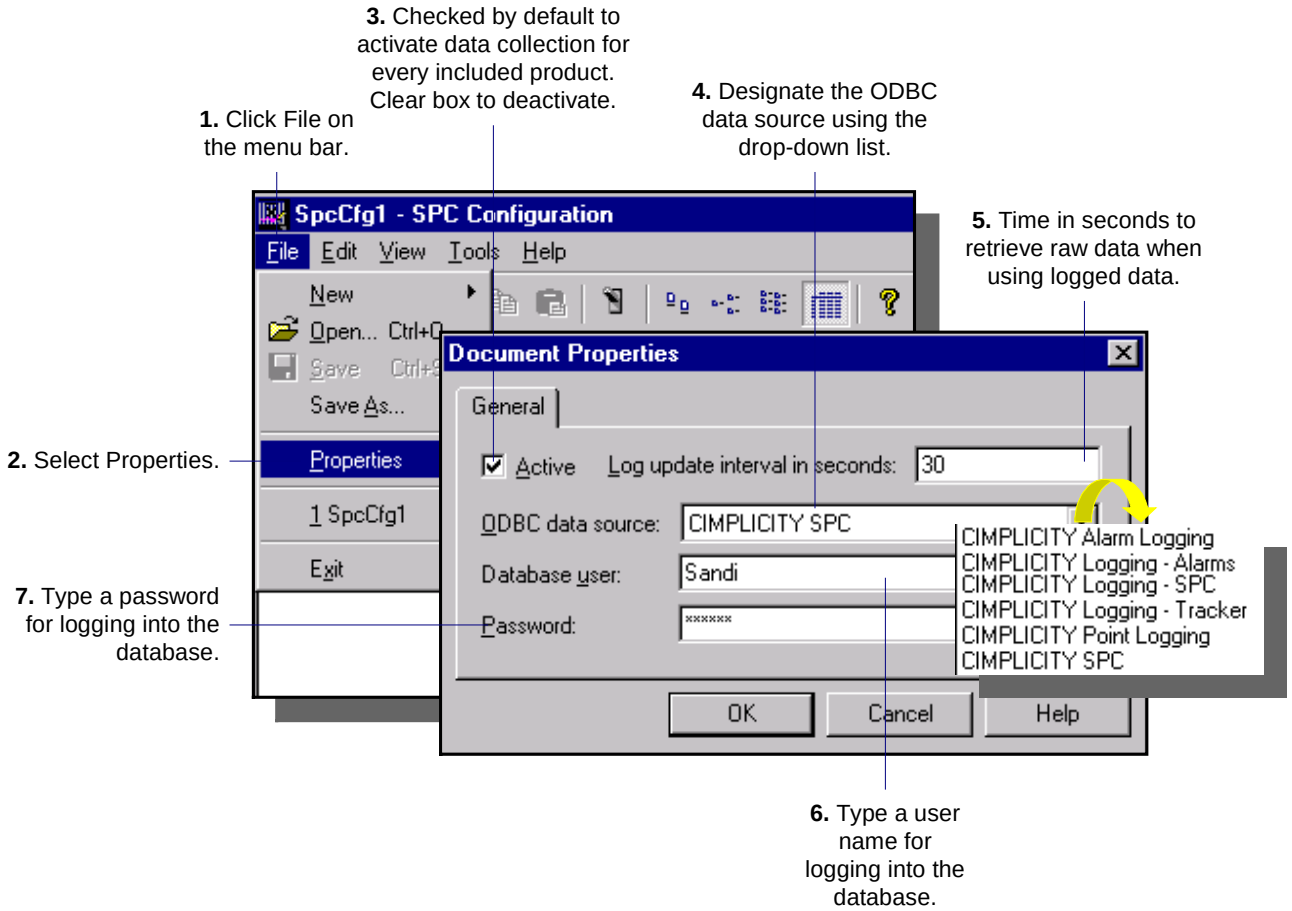
- activate or deactivate data collection for every included product.
- specify basic parameters including the:

  logged update interval in seconds.

  ODBC data source.
- limit user access.

To define Document properties:

1. Click File on the menu bar of the document window.
2. Select Properties to display the Document Properties dialog box—see figure.
3. The Active box is checked by default to activate data collection for the document; clear to disable option. Note that the Database Logger must be configured for the project to enable the SPC Data Collector.


3. Checked by default to activate data collection for every included product. Clear box to deactivate.
4. Designate the ODBC data source using the drop-down list.
1. Click File on the menu bar.
5. Time in seconds to retrieve raw data when using logged data.
SpcCfg1 - SPC Configuration
File Edit View Tools Help
New
Open... Ctrl+O
Save Ctrl+S
Save As...
Properties
1 SpcCfg1
Exit
Document Properties
General
Active
Log update interval in seconds: 30
ODBC data source: CIMPLICITY SPC
Database user: Sandi
Password: ******
CIMPLICITY Alarm Logging
CIMPLICITY Logging - Alarms
CIMPLICITY Logging - SPC
CIMPLICITY Logging - Tracker
CIMPLICITY Point Logging
CIMPLICITY SPC
OK
Cancel
Help
2. Select Properties.
7. Type a password for logging into the database.
6. Type a user name for logging into the database.

4. In the Log update interval in seconds field, type an integer to define the frequency in seconds raw data will be retrieved from the database when using logged data as input.
5. Use the default ODBC data source, or select a different data source from the drop-down list.
6. In the Database user field, type a name for logging into the ODBC data source.
7. In the Password field, type a password for logging into the ODBC data source.

Note: SPC creates and uses a default data source called CIMPLICITY SPC. This default data source is an Access (*.mdb) file called SPC.mdb. It is stored in the ARC subdirectory of where you installed CIMPLICITY (Usually C:\CIMPLICITY\HMI\ARC).

Products

After you define the basic parameters for your document, you can add the products that will be included in the group. To do this, create a folder for each product. The Product folder will be a subfolder of the main Products folder.

Adding a New Product

Add a new product to SPC by creating a new product folder—see figure below.

To create a Product folder:

Method 1 – File menu

1. Click File on the menu bar.
2. Select New**.**
3. Select Product from the pullout menu.

Method 2 – Popup menu

1. Select the Products folder.
2. Right-click and select New Product from the popup menu.

Result: Using either method, the Product Properties dialog box opens.

Defining Product Properties

The Product Properties dialog box is where you identify each product that is added to the document by designating the following—see figure:

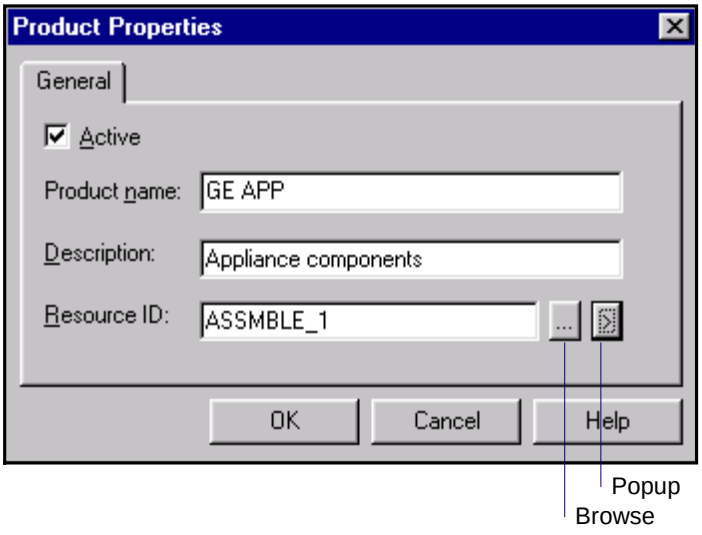
- Data collection (activate or deactivate)
- Product name
- Description
- Resource ID

To specify Product properties:

1. The Active box is checked by default to activate data collection for the product; clear to disable option. Note that the Document must also be active for collection.
2. In the Product name field, type a name for the product folder.
3. Optionally type a Description.
4. In the Resource ID field, indicate the resource to be used by alarms generated for this product as follows:

   Click ... to browse for an existing resource in the Select a Resource dialog box, or

   Click > to designate a New Resource.



Variable Quality Characteristics

Once you have created a new product, define the variables to be tracked for each. Information that you enter in the Variable Quality Control Characteristics dialog box is used to configure a detailed Histogram and either an XBar-R or XBar-S chart set.

Use the Variable Quality Characteristics Properties dialog box to create and define characteristics as follows:

- **General characteristics**—including the name of the characteristic; whether or not data is to be collected for the characteristic; whether you want to use an XBar-S or XBar-R chart set; the subgroup size and gap size.
- **Collection characteristics**—specifies the data collection method.
- **Limits**—sets control and specification limits.
- **Alarms**—indicates alarming and control tests to be performed on the data.

Caution: If you enter specific values during configuration and an inconsistency is detected, SPC will display an error message. You cannot save the configured data until the error is corrected.

Example

You select Values to enter a variable's control limits and enter 25 for an Upper Control Limit and 50 for a Lower Control Limit. SPC will display the following error message, “The upper control limit must be greater than the center line and the center line must be greater than the lower control limit.”

Note: If you use Points for general characteristics on limits rather than specific values, SPC will alert the user when the values become specific at runtime. If SPC detects configuration inconsistencies, it will display an $SPC_ADMIN_ALARM in the Alarm Viewer. *See "SPC Administration Alarms.”*

Adding a New Variable Quality Characteristic

To add a Variable Quality Characteristic, do one of the following:

Method 1 – File menu

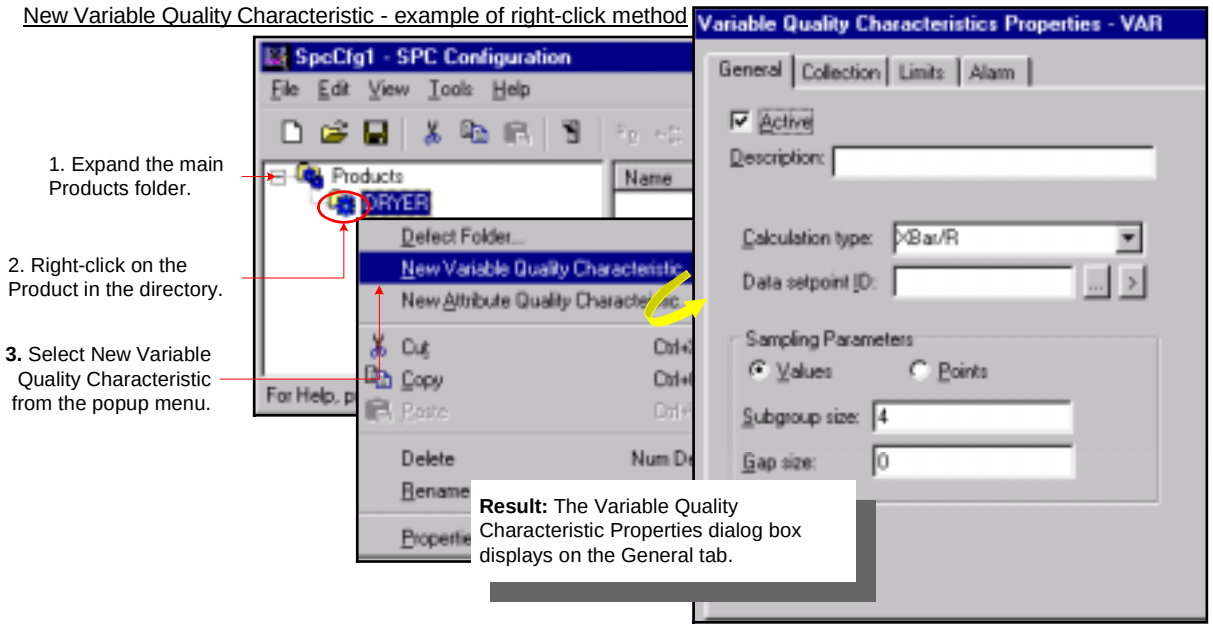
1. Expand the Products folder and select the product.
2. Click File on the menu bar.
3. Select New.
4. Select Variable Quality Characteristic from the pullout menu.

Method 2 – Popup menu

1. Expand the Products folder and select the product.
2. Right-click and select New Variable Quality Characteristic from the popup menu.

Result: Using either method, the Variable Quality Characteristics Properties dialog box opens, with the General tab displayed—see figure.

New Variable Quality Characteristic - example of right-click method



Note: When you create a new characteristic, SPC calls it VAR in the document tree. If there is more than one variable that you have not named, SPC numbers them in the order they were created and lists the description you input in the General tab of the Properties dialog box. You can rename the variable at any time in the directory.

Specifying a Variable's General Characteristics

Begin configuring a new variable by defining its general characteristics using the General tab of the Variable Quality Characteristics Properties dialog box. Enter the following information:

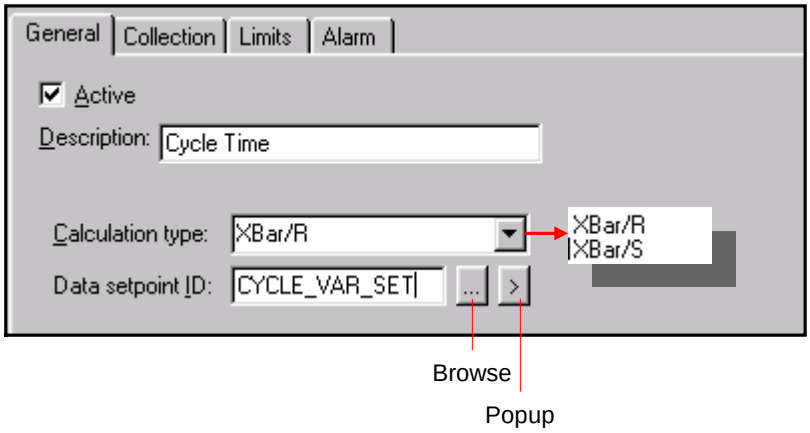
1. A description of the variable.

2. Whether it will have an XBar-R or XBar-S chart set.
3. Sampling parameters including:
   - whether the sample parameters will be based on Points or specific values.
   - subgroup sample size.
   - gap size.

To specify general characteristics:

1. Click the General tab—see figure.
2. The Active box is checked by default to activate data collection for the product; clear to disable option. Note that the Document must also be active for collection

Variable Properties dialog-General tab



3. Type a Description for the variable, which will display in the directory.
4. Select XBar-R or XBar-S chart set from the Calculation type drop-down list.
5. If you want to use the current XBar-R or S value elsewhere in your project, or download them to a device, indicate the floating-point array Point of two (2) elements in the Setpoint ID field. The array contains numbers for XBar and range or XBar and standard deviation. Do one of the following:

   Click ... to browse for an existing Point in the Select a Point dialog box, or

   Click > to designate a New Point.
6. Click Values or Points to specify the sampling parameters—see next sections for details.

Using Points to Specify Sampling Parameters

You can use Points to specify sampling parameters as described below. When you use Points, values can be changed at runtime—see figure.

To specify Points as sampling parameters:

1. In the Sampling Parameters group, click Points radio button.
2. Select a Point to indicate the Subgroup size. Note that the same size can be changed at runtime. Do one of the following:

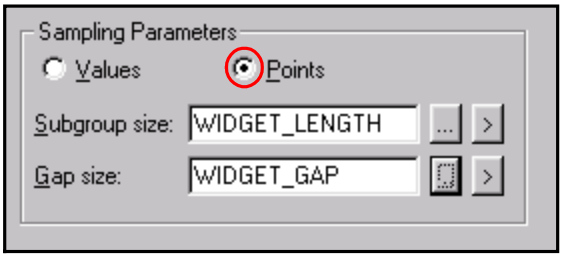
Click to browse for an existing Point in the Select a Point dialog box, or

Click to designate a New Point.

2. Select a Point to indicate the Gap size; that is, how many units will be skipped before the next sample is taken, as follows:

   Click to browse for an existing Point in the Select a Point dialog box, or

   Click to designate a New Point.

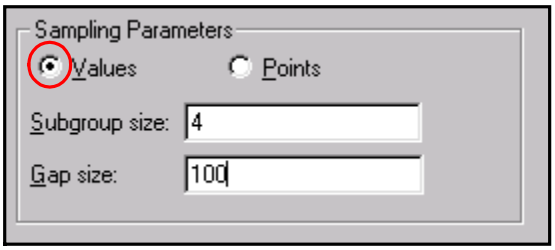


Using Values to Specify Sampling Parameters

You can use Values to specify sampling parameters as described below—see figure.

To specify Values as sampling parameters:

1. In the Sampling Parameters group, click the Values radio button.
2. Type a value for the Subgroup size (sample size).
3. Type a value for the Gap size; that is, how many units will be skipped before the next sample is taken.



Defining a Variable's Collection Characteristics

Define SPC's collection method and the source of the variable input data using the Collection tab in the Variable Quality Characteristic Properties dialog box.

Collection methods include:

- **Automatic Data Collection:** either Point, Logged or None. The type selected will activate corresponding fields in the dialog box. When you use an Automatic Collection method, you can also use:

  the same data source for multiple attributes (Match Point)

  a batch process (Batch Point ID or Batch Column ID)

- **Point Data Collection**: one or more CIMPLICITY Points are specified, along with start and end indices for array Points, and any engineering unit conversion (default).
- **Logged Data Collection**: retrieves data from an ODBC database table. Define the ODBC data source, table and column names.
- **None:** specify whether or not manual entry will be allowed. Manual entry can be allowed for any type of data collection you choose. SPC automatically includes manual entry when you select None. Select this option to prevent automatic data collection.

Point Collection for a Variable

You can designate Points for data collection using the Collection tab of the Variable Quality Characteristics Properties dialog box. Here, the scope of the collection can also be specified.

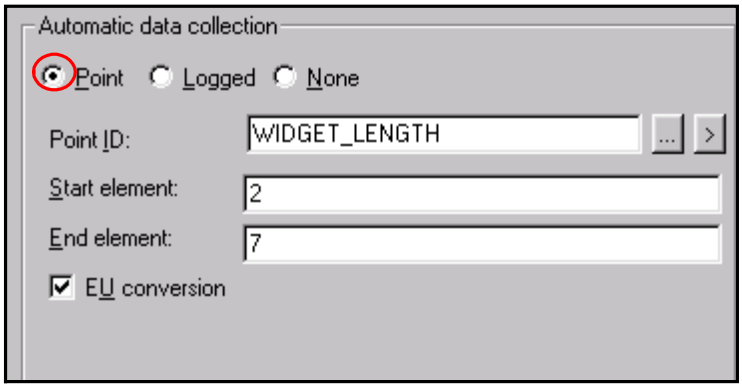
To specify Points for data collection:

1. Click the Collection tab.
2. Click the Point radio button—see figure.
3. Identify the Point ID (data source) from which the SPC Data Collector retrieves data. The Point ID *cannot* have a Text type. Do one of the following:

   Click [...] to browse for an existing Point in the Select a Point dialog box, or

   Click [>] to designate a New Point.
4. When using any array, specify the number where SPC should begin to collect values in the Start element field. Note that the default is 0.
5. When using any array, specify the number where SPC should finish to collect values in the End element field. Note that the default is 0.
6. Check the EU conversion box if the SPC Data Collector is to use the EU value(s) for the Point. Clear if the SPC Data Collector should use the raw value(s) for the Point

Variable-Collection Properties-Point



7. Select a Point to indicate the Match Point ID (numeric Point only) in order to use the same data source that is identified by the Point ID for multiple variables. Do one of the following:

   Click ... to browse for an existing Point in the Select a Point dialog box, or

   Click > to designate a New Point.

8. In the Match value field, enter the value to be matched against the Match Point ID to determine whether the collected data applies to this specific variable quality characteristic.

   For example, the collected Point ID (data source) may be used to measure a variable (for example, length) for several products (Product 1, Product 2, Product 3). You can enter a Match Point ID value of 1 to measure length for Product 1, and 2 to measure length for Product 2.

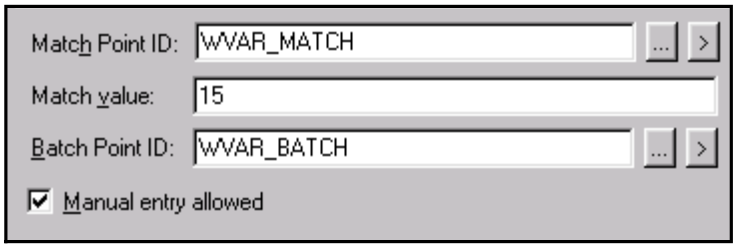
9. If this is a batch process, select a Batch Point ID. This will allow you to distinguish between different batches for the same Product Quality Characteristic. The value of the Batch Point is associated with the calculated data and can be used as search criteria for charts and reports. Do one of the following:

   Click ... to browse for an existing Point in the Select a Point dialog box, or

   Click > to designate a New Point.

10. Check the Manual entry allowed box to enable manual data entry for SPC chart sets at runtime; clear to disable option.

Variable-Collection Properties-Point



Logged Collection for a Variable

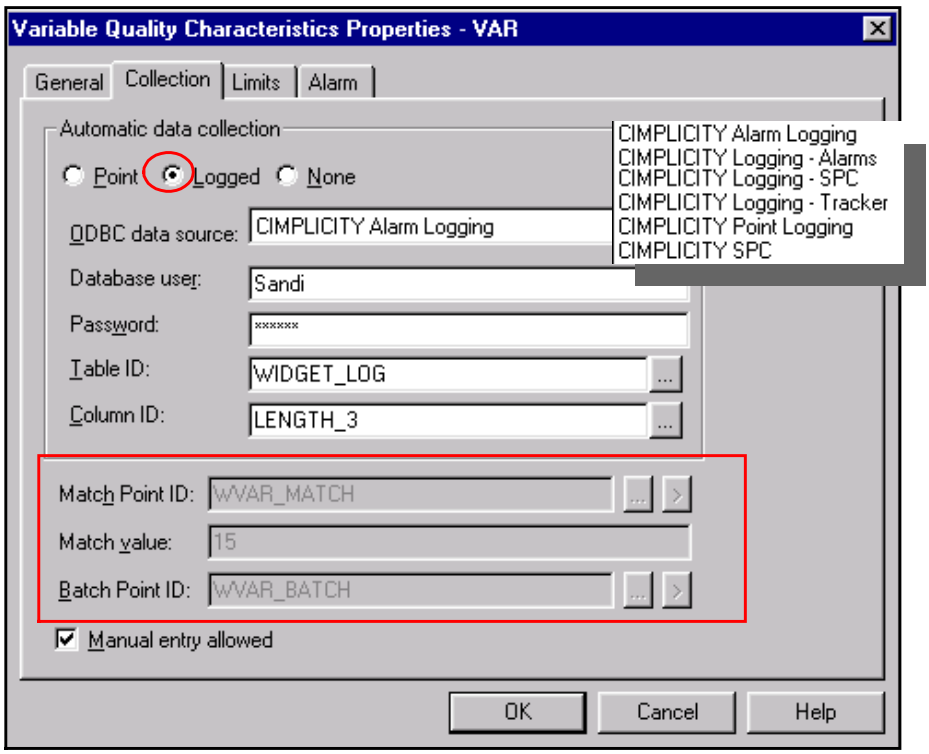
If you select Logged, SPC retrieves data from an ODBC database table that has already been updated by CIMPLICITY HMI. Define logged collection in the Variable Quality Characteristics Properties dialog box.

Note: SPC logs all of its data. Therefore, the Logged option is not necessary for saving data. It refers to using an additional data source for input. The Point collection method is more efficient.

To specify Logged for data collection:

1. Click the Collection tab—see figure.
2. Click the Logged radio button.
3. Use the ODBC data source drop-down list to select the name of the database from which SPC will retrieve data.

Variable-Collection Properties-Logged



4. In the Database user field, type a name for the user when logging into the ODBC data source.
5. In the Password field, type a password for the user when logging into the ODBC data source.

6. Click ... to browse for the Table ID where data is located.
7. Click ... to browse for the Column ID where data is located.
8. Check the Manual entry allowed box to enable manual data entry for SPC chart sets at runtime; clear to disable option.

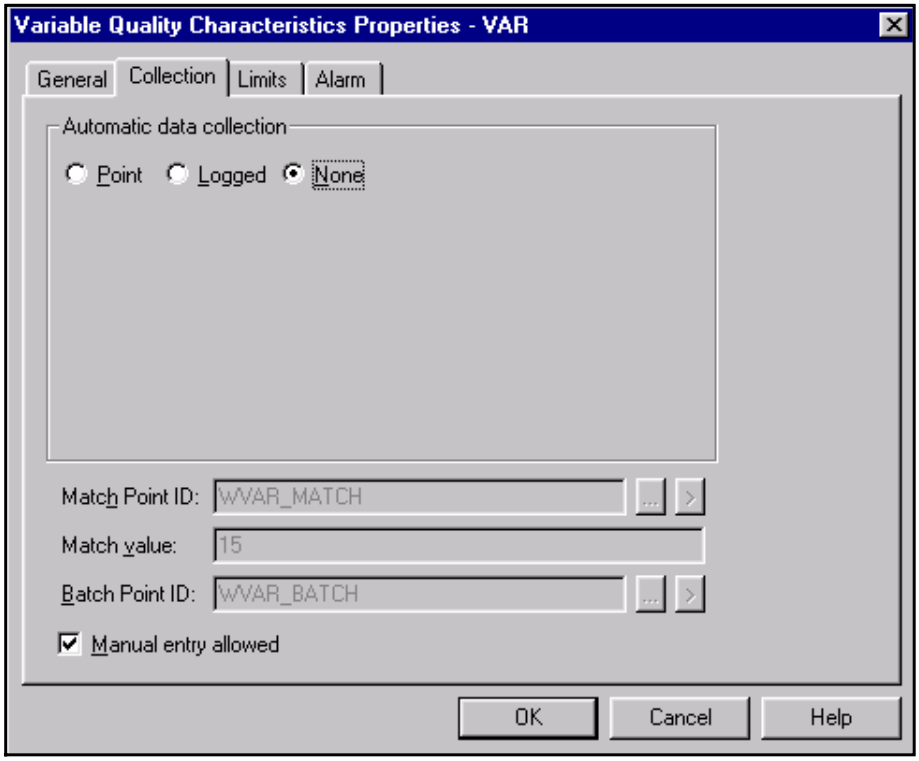
No Collection for a Variable

If you choose to enter your own data, do not designate a data collection source.

To specify None for data collection:

1. Click the Collection tab.
2. Click the None radio button—see figure.

Result: The Manual entry allowed box is checked by default to enable manual data entry.



Setting Limits for Variable Quality Characteristics

Once you have defined the variable's general characteristics and collection methods, you are ready to set control limits for your XBar-R or XBar-S chart sets in the Variable Quality Characteristics Properties dialog box.

Included are:

- Control limits, and
- Specification limits.

Control Limits for a Variable

In order to set control limits for your chart sets, SPC provides you with several different options. If you know the limits that you want to set, you can use Points or Values. If the process is new and you would like to have limits calculated automatically for you, you can use the auto recalculation features. Whatever your preference, SPC provides you with an option.

You can specify values for control limits by:

- entering values, or
- using auto recalculation.

You can enter values as:

- (specific) values.
- Points.

Caution: If you enter specific values during configuration and SPC detects an inconsistency, it will display an error message and will not allow you to save the configuration until you correct the error.

Example

You select Values to enter a variable's control limits and enter 25 for an Upper Control Limit and 50 for a Lower Control Limit. SPC will display the following error message, "The upper control limit must be greater than the center line and the center line must be greater than the lower control limit."

Note: If you use Points for general characteristics on limits rather than specific values, SPC will alert the user when the values become specific at runtime. If SPC detects configuration inconsistencies, it will display an $SPC_ADMIN_ALARM in the Alarm Viewer. *See "SPC Administration Alarms."*

SPC Auto Recalculation Feature

One of the many advantages SPC offers is its ability to automatically calculate the control limits for a process. This particularly comes in handy if your process is new and you want the SPC program to generate control limits.

SPC offers two options to automatically recalculate control limits:

- Auto recalculation: is used in place of Values or Points. Once the control limits are automatically calculated, select either Values or Points for the life of the process.
- Force Auto Recalc: is used in addition to Values or Points. This option provides the flexibility to reset control limits during runtime. As a result, when you send an application to production, you can have SPC recalculate the control limits so that they are accurate for the process. Once the control limits are automatically calculated, disable the Force Auto Recalc option.

Important: The Quality Control rules you have always followed for control limits still apply to both SPC automatic recalculation options, as follows:

- When your process is new or in optimum condition, calculate the limits using the Auto Recalculation or Force Auto Recalculation option.
- Once you determine that SPC has automatically collected enough data to calculate the correct control limits, disable the automatic calculation option.
- The calculated control limits are then used for the life of the process.
- Remember that the control limits produced by auto recalculation are valid only when your process is "in control." If you calculate them while your process is going "out of control," then the limits will be incorrect.

Control Limits for (Specific) Values

You can use your own criteria to set control limits using the Values option in the Limits tab of the Properties dialog box. Also, you can use the Force Auto Recalc feature to override limit values set in the dialog box.

To specify Values for control limits:

1. Click the Limits tab.
2. Click the Values radio button—see figure below.
3. Enter the values for the XBar chart's control limits as follows:

   XBar UCL—Upper control limit.

   XBar CL—Center line.

   XBar LCL—Lower control limit.

4. Enter the values for the R or S chart's range or standard deviation as follows:

   R/S UCL—Upper control limit.

   R/S CL—Center line.

   R/S LCL—Lower control limit.

5. If you want to use the current control limits elsewhere in your project, or download them to a device, indicate the floating-point array Point of six (6) elements in the Setpoint ID field. The Point contains six elements for all values to be set in the following order: XBar LCL, XBar CL, XBar UCL, R/S LCL, R/S CL, R/S UCL. Do one of the following:

   Click to browse for an existing Point in the Select a Point dialog box, or

   Click to designate a New Point.

6. Indicate the Specification limits for Histogram analysis as follows:

   Lower – type the Lower Specification Limit (LSL).

   Upper – type the Upper Specification Limit (USL).

To use auto recalculation to set control limit values:

- In the Force auto recalc field, indicate the Boolean Point ID that has been created to override the value control limits at runtime. This feature can be configured to be turned on or off at runtime.

  Point On

  When the Point is on (set to TRUE), auto recalculation is activated and the XBar-R/S control limits are recalculated. Pre-set values are ignored.

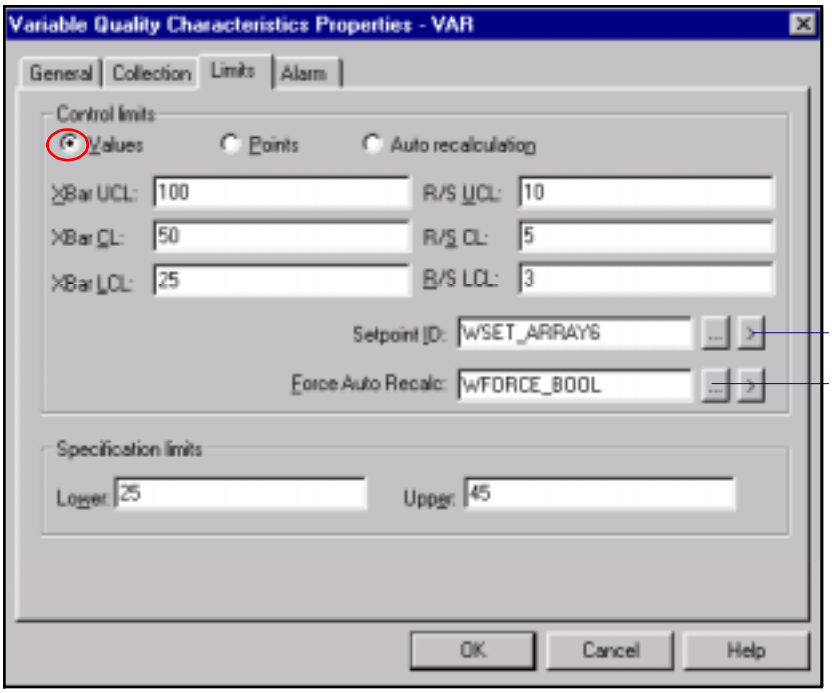
  Point Off

  When the Point is off (set to FALSE), auto recalculation is deactivated and the last calculated values are used. Pre-set values are ignored until the data collector is restarted or dynamically refreshed.

  Do one of the following—see figure:

  Click [...] to browse for an existing Point in the Select a Point dialog box, or

  Click [>] to designate a New Point.



Note: Whenever the Force Auto Recalc Point is set to either TRUE or FALSE, the data collector will drop the current sample and start fresh.

Points Control Limits

In order to use Points to set control limit criteria, use the Points option in the Limits tab of the Properties dialog box. Also, you can use the Force Auto Recalc feature to set the Point values for control limits.

To specify Points for control limits:

1. Click the Limits tab.
2. Click the Points radio button—see figure.
3. Enter the a different Point for the XBar UCL, CL and LCL control limits as follows:

   Click ... to browse for an existing Point in the Select a Point dialog box, or

   Click > to designate a New Point.
4. Enter the a different Point for the R/S UCL, CL and LCL range or standard deviation as follows:

   Click ... to browse for an existing Point in the Select a Point dialog box, or

   Click > to designate a New Point.
5. If you want to use the current control limits elsewhere in your project, or download them to a device, indicate the floating-point array Point of six (6) elements in the Setpoint ID field. The Point contains six elements for all values to be set in the following order: XBar LCL, XBar CL, XBar UCL, R/S LCL, R/S CL, R/S UCL. Do one of the following:

   Click ... to browse for an existing Point in the Select a Point dialog box, or

   Click > to designate a New Point.
6. Indicate the Specification limits for Histogram analysis as follows:

   Lower – type the Lower Specification Limit (LSL).

   Upper – type the Upper Specification Limit (USL).

To use auto recalculation to set Point values:

- In the Force auto recalc field, indicate the Boolean Point ID that has been created to override the value control limits at runtime. This feature can be configured to be turned on or off at runtime.

  Point On

  When the Point is on (set to TRUE), auto recalculation is activated and the XBar-R/S control limits are recalculated. The data collector will set the control Points (specified in the dialog box fields) to the calculated values.

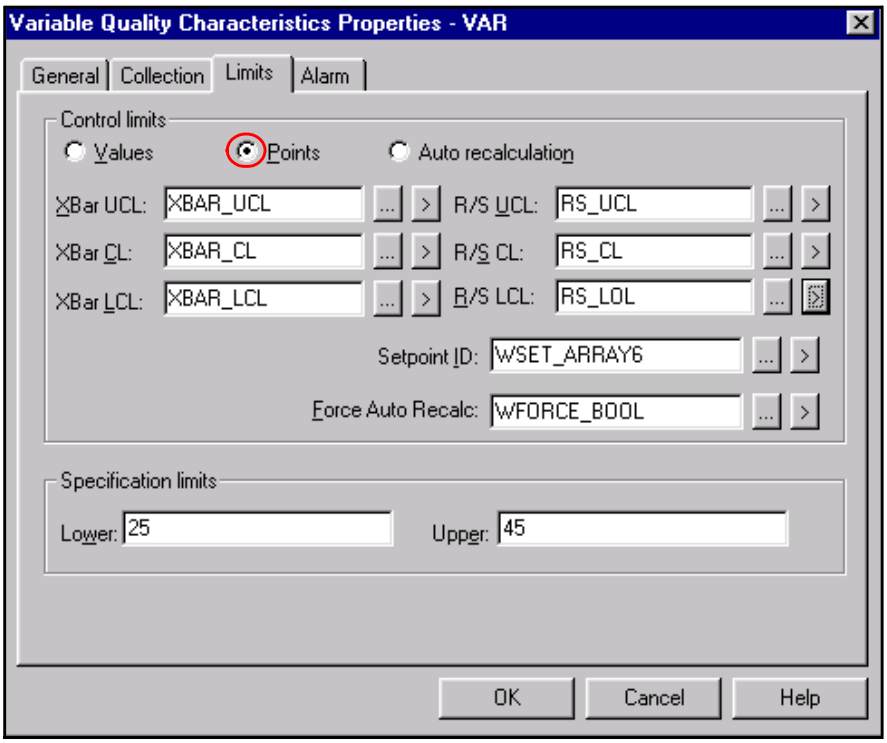
  Point Off

  When the Point is off (set to FALSE), auto recalculation is deactivated and the last calculated values are used until the control Points are updated.

  Do one of the following—see figure:

  Click [...] to browse for an existing Point in the Select a Point dialog box, or

  Click [>] to designate a New Point.



Note: Whenever the Force Auto Recalc Point is set to either TRUE or FALSE, the data collector will drop the current sample and start fresh.

Auto Recalculation Control Limits

In order to automatically set control limits for a new process, or when your process is in optimum condition, use the Auto Recalculation option.

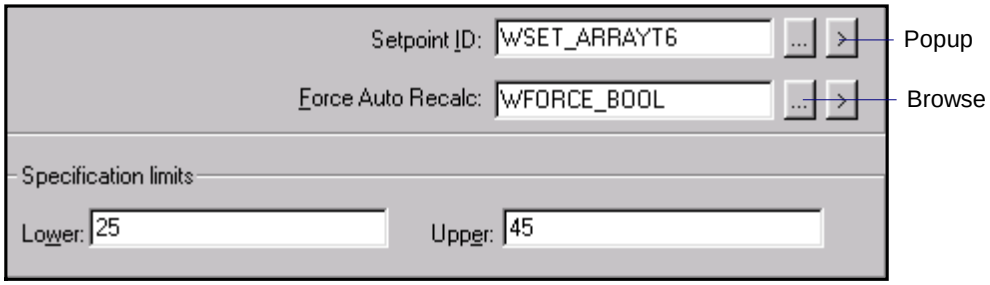
To use auto recalculation to automatically set values:

1. Click the Limits tab.
2. Click the Auto recalculation radio button—see figure.
3. If you want to use the current control limits elsewhere in your project, or download them to a device, indicate the floating-point array Point of six (6) elements in the Setpoint ID field. The Point contains six elements for all values to be set in the following order: XBar LCL, XBar CL, XBar UCL, R/S LCL, R/S CL, R/S UCL. Do one of the following:

   Click [...] to browse for an existing Point in the Select a Point dialog box, or

   Click [>] to designate a New Point.

Variables Properties dialog-Limits tab-Auto Recalculation Option



4. In the Force auto recalc field, indicate the Boolean Point ID that has been created to override the value control limits at runtime. This feature can be configured to be turned on or off at runtime.

   Point On
   When the Point is on (set to TRUE), auto recalculation is activated and all previous values are ignored.
   Point Off
   When the Point is off (set to FALSE), auto recalculation is deactivated and the data collector continues to use the last calculated values.

   Once enough data has been collected to calculate valid control limits, deactivate auto recalculation and use Values or Points to set control limits for your process in the dialog box.

   Do one of the following:

   Click [...] to browse for an existing Point in the Select a Point dialog box, or

   Click [>] to designate a New Point.

5. Indicate the Specification limits for Histogram analysis as follows:

   Lower – type the Lower Specification Limit (LSL).

   Upper – type the Upper Specification Limit (USL).

Note: Whenever the Force Auto Recalc Point is set to either TRUE or FALSE, the data collector will drop the current sample and start fresh.

Setting Alarms for Variable Quality Characteristics

SPC can track several different types of occurrences to warn you if a process is slightly off, even if production has not exceeded its control limits on a regular basis. As a result, you can anticipate and handle potential problems before they occur.

Use the Alarm tab in the Variable Quality Characteristics Properties box to specify the:

- type of alarm that will be triggered.
- Setpoint ID.
- control test criteria that will initiate alarms or change Setpoints.

Alarms and Setpoints

When one of the control tests meets your criteria for issuing a warning, it will generate the type of warning you configure, including:

- an alarm to alert operators.

  If alarms are generated for more than one control test, they will stack up and be deleted according to specifications you enter in the CIMPLICITY HMI Alarm Configuration.

- a Setpoint that will change to the number (1-8) of the XBar test that is in an alarm state.

  Setpoints provide you with a way to automate corrective action. You can write scripts that trigger the appropriate action whenever the criteria have been met for one of the control tests. The value of the Setpoint reflects the last test for which an alarm was triggered.

To specify an alarm and Setpoint:

1. Click the Alarm tab—see figure.
2. You can select the $SPC_ALARM system Alarm ID, or you can create your own alarm in the Alarm ID field. Use the SPC_ALARM type when creating your own alarm. Do one of the following:

   Click to browse for an existing Point in the Select a Point dialog box, or

   Click to designate a New Point.

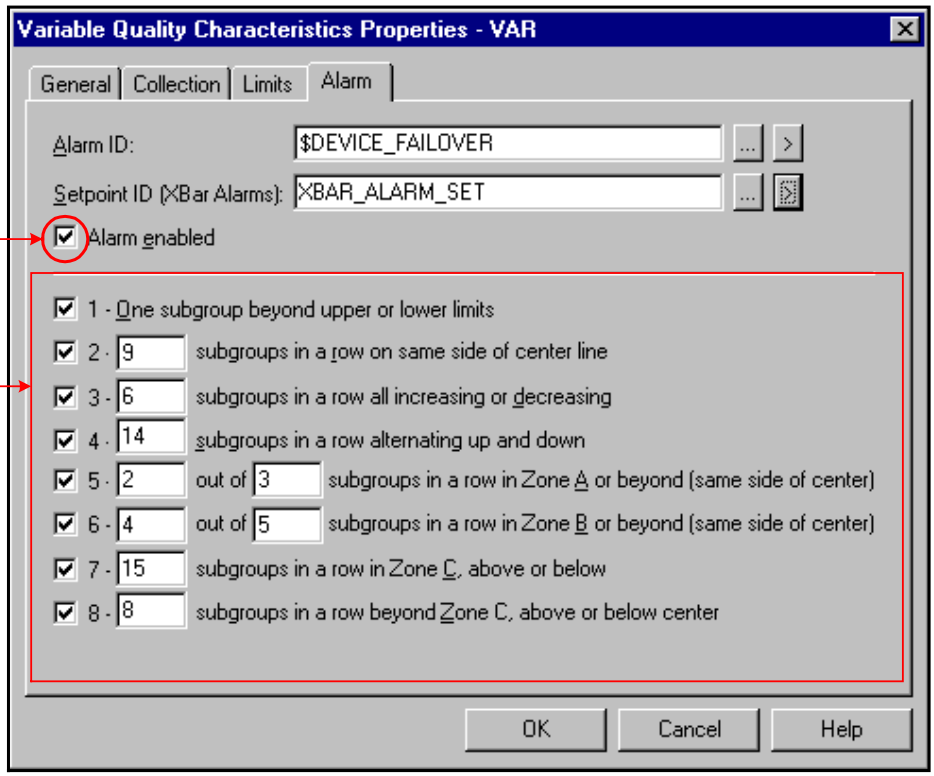
   The alarm message for SPC alarms consists of the following strings:

   - Document Name.
   - Product Name.
   - Quality/Defect Characteristic Name.
   - A description of the control check that triggered the alarm.
   - The value of the sample that triggered the alarm.

3. In the Setpoint ID field, indicate a Point to be set when an SPC alarm occurs as follows:

   Click [...] to browse for an existing Point in the Select a Point dialog box, or

   Click [>] to designate a New Point.


Variable Quality Characteristics Properties - VAR
General
Collection
Limits
Alarm
Alarm ID:
$DEVICE_FAILOVER
Setpoint ID (XBar Alarms):
XBAR_ALARM_SET
Alarm enabled
1 - One subgroup beyond upper or lower limits
2 - 9 subgroups in a row on same side of center line
3 - 6 subgroups in a row all increasing or decreasing
4 - 14 subgroups in a row alternating up and down
5 - 2 out of 3 subgroups in a row in Zone A or beyond (same side of center)
6 - 4 out of 5 subgroups in a row in Zone B or beyond (same side of center)
7 - 15 subgroups in a row in Zone C, above or below
8 - 8 subgroups in a row beyond Zone C, above or below center
OK
Cancel
Help
Check to enable alarming.
Check boxes to activate control tests and indicate test criteria.

4. Check the Alarm enabled box to activate alarming for the variable; clear to disable option.
5. Proceed to next section, *"Criteria for Variable Control Tests,"* for complete instructions and information about each of the available control test options.

Criteria for Variable Control Tests

SPC plots the averages of the samples you define on XBar charts in the XBar-R and XBar-S chart sets. It is the XBar charts that display the zone in which these averages fall. At runtime, each subgroup that meets one or more of the selected test criteria will be displayed with a special character (the default is a red asterisk).

The following zones are used in these tests:

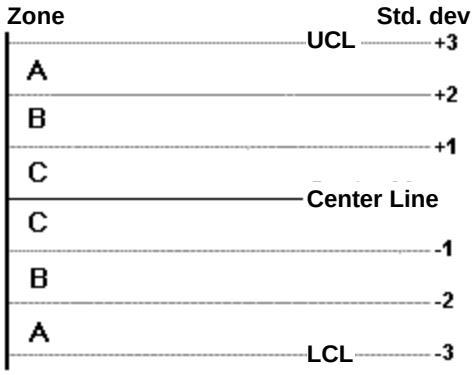
- Zone C is the area up to one standard deviation from the center line.
- Zone B is the area between one and two standard deviations from the center line.
- Zone A is the area between two and three standard deviations from the center line.

Performing multiple control tests:

In the Alarm tab of the Variable Quality Characteristics Properties dialog box, you can run multiple control tests on your data by checking the appropriate boxes. At runtime, each data value will be compared with all of the selected alarm conditions and plotted on your configured SPC chart. When you position your cursor over the red asterisk (default character), a detailed tool tip will display with the date, time, point value and failed test data, i.e. the control test number(s).

Note: When you create a control chart, you can select samples for exclusion. *See "SPC Control Test Exclusion Mode" for instructions.*

The following example depicts the standard:



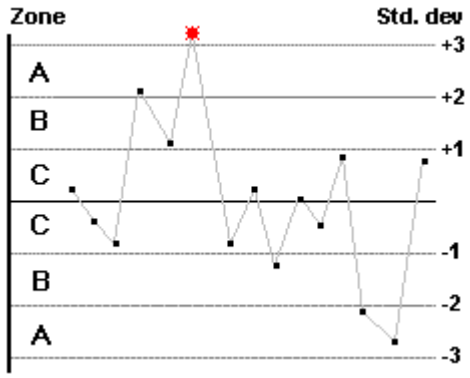
To perform variable control tests:

1. Check the appropriate box in the Alarms tab for each of the tests to be performed.
2. View test results by:
   - accessing a configured SPC chart to view runtime data, or
   - configuring a new SPC chart.

Control Test 1: One subgroup beyond upper or lower limits

This test checks to see if any subgroups on the chart have a value greater than the upper control limit or less than the lower control limit. Subgroups that meet test criteria will be marked with a red asterisk.

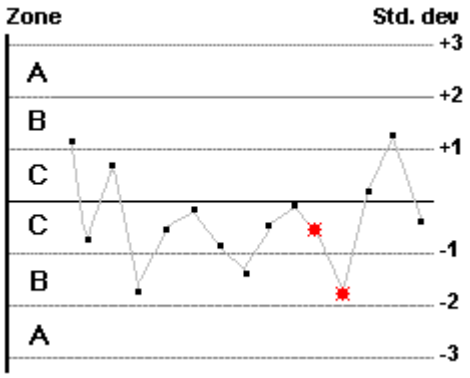
For example:



Control Test 2: N subgroups in a row on same side of center line

This test checks to see if N subgroups in a row are on the same side of the center line. The Nth subgroup and all following subgroups that meet the test criteria will be marked with a red asterisk.

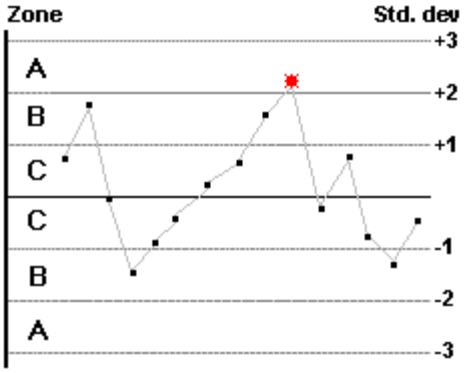
For example, if N=8:



Control Test 3: N consecutive subgroups in a row all increasing or decreasing

This test checks to see if N subgroups in a row are increasing in value or decreasing in value. The Nth subgroup and all following subgroups that meet the test criteria will be marked with a red asterisk.

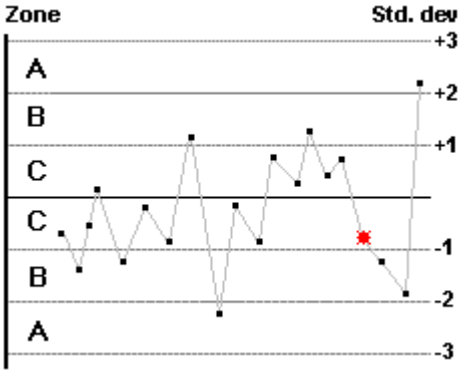
For example, if N=6:



Control Test 4: N subgroups in a row, alternating up and down

This test checks to see if N subgroups in a row are alternately increasing in value then decreasing in value. The Nth subgroup and all following subgroups that meet the test criteria will be marked with a red asterisk.

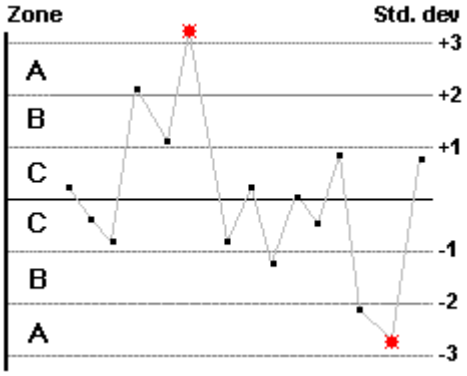
For example, if N=14:



Control Test 5: M out of N subgroups in a row in Zone A or beyond (same side of center)

This test checks to see if M out of N subgroups in a row on the *same* side of the center line are in Zone A or beyond. The Mth subgroup that meets the test criteria will be marked with a red asterisk.

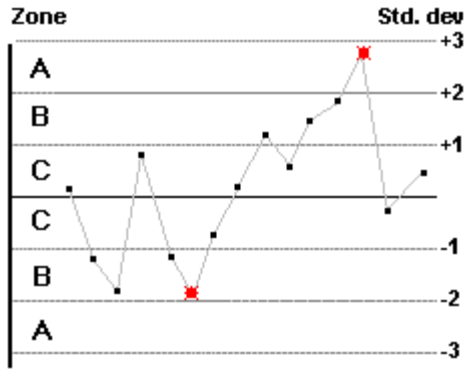
For example, if M=2 and N=3:



Control Test 6: M out of N subgroups in a row in Zone B or beyond (same side of center)

This test checks to see if M out of N subgroups in a row on the *same* side of the center line are in Zone B or beyond. The Mth subgroup that meets the test criteria will be marked with a red asterisk.

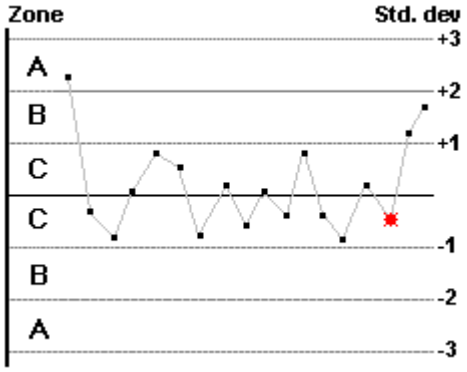
For example, if M=4 and N=5:



Control Test 7: N subgroups in a row in Zone C, above or below center

This test checks to see if N subgroups in a row lie in Zone C on either side of the center line. The Nth subgroup and all the following subgroups that meet the test criteria will be marked with a red asterisk.

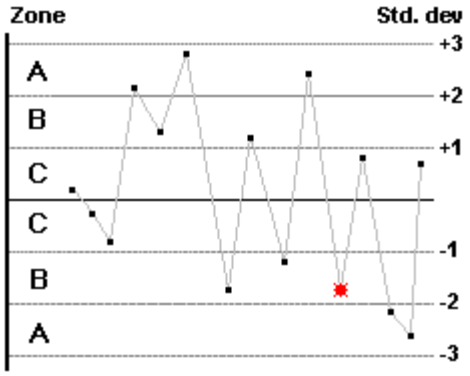
For example, if N=15:



Control Test 8: N subgroups in a row beyond Zone C, above or below center

This test checks to see if N subgroups in a row lie beyond Zone C on either side of the center line. The Nth subgroup and all following subgroups that meet the test criteria will be marked with a red asterisk.

For example, if N=8:



SPC Control Test Exclusion Mode

A process must be in control when you determine the control limits for your process. However, when you calculate the control limits there may be some variation due to *special causes*, such as samples being taken when your machines are warming up. When there is this kind of variation, SPC exclusion mode allows you to manually select samples for exclusion from control limit calculation.

Important: When calculating control limits, variation must be due to *common causes* only. Variation cannot be attributable to *special causes* or control limits are not valid.

SPC Exclusion Mode is enabled on the following chart types:

- XBar-R
- XBar-S
- p
- nP
- c
- u

The SPC exclusion process evolves as follows:

1. During runtime, when an SPC chart is on screen, the operator selects Exclusion Mode. An **X** appears at the top left of CimView, indicating that Exclusion Mode is active.
2. The operator selects the samples to exclude.
3. SPC automatically performs a recalculation based on the exclusions and updates the control limits displayed on the chart.

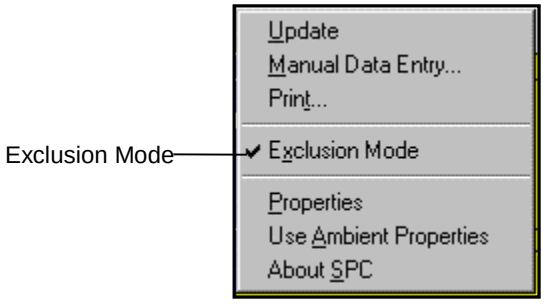
To toggle SPC Exclusion Mode On/Off:

SPC comes with two methods to toggle Exclusion Mode On/Off. Both methods are accessed through CimView when an SPC chart is on screen.

Method 1 – Popup menu

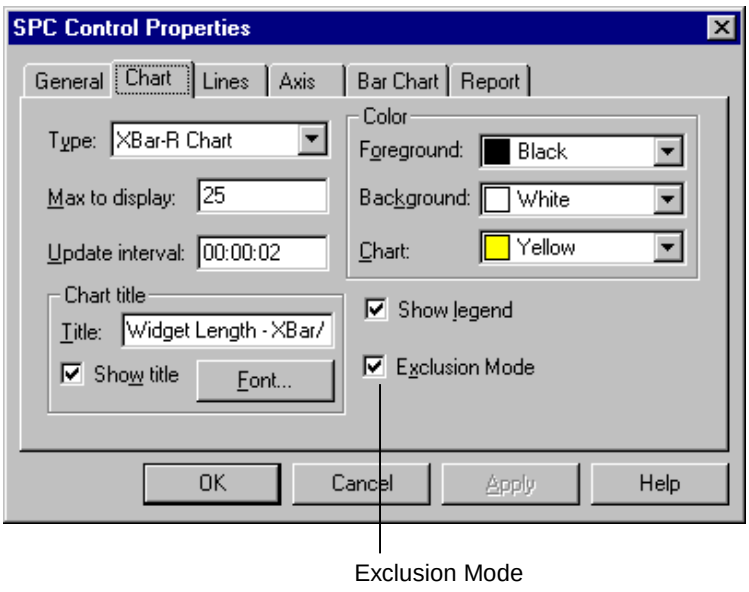
1. Right-click on an SPC chart that is display on an SPC CimView screen.
2. Select Exclusion Mode from the popup menu—see figure.

Result: Exclusion Mode is checked on the popup menu signifying the feature is active.



Method 2 – Double-click

1. Double-click the SPC chart to display the SPC Control Properties dialog box.
2. Click the Chart tab.
3. Check the Exclusion Mode box.



Application Engineering Note: By using the **`ExclusionMode`** property, an applications engineer can create different ways to let an operator toggle exclusion mode on and off.

Excluding/Returning Samples in Control Chart Calculation

During runtime, when SPC is in Exclusion Mode, an operator can exclude one or more samples from calculation. An operator can also re-include samples.

As soon as you toggle the exclusion state of a sample, SPC immediately recalculates the control limits displayed on the chart.

The following symbols allow you to view exclusion status.

- **X** In the upper left-hand corner of the SPC control chart –Exclusion mode is on.
- ● Representing a sample–Sample is included in the calculation.
- **X** Representing a sample–Sample is excluded from calculation.

To exclude samples from a control chart when SPC is in Exclusion Mode:

Method 1

Click on a dot that represents the sample to toggle its exclusion state.

Result: The dot will change to an X indicating that the sample is excluded—see figure.

Method 2

1. Click on a corner of the group of sample to be excluded.

2. Drag the cursor over the entire groups of samples. Note that a box will appear around the selected samples.

3. Release the mouse button.

Result: Each dot that represented an included sample changes to an X, indicating the sample is now excluded—see figure.

Example of Excluding Bad Data From SPC Charts

1a Four samples (1a) are beyond Zone A. The reason is explainable

1b An X indicates that SPC is in Exclusion Mode (1b).

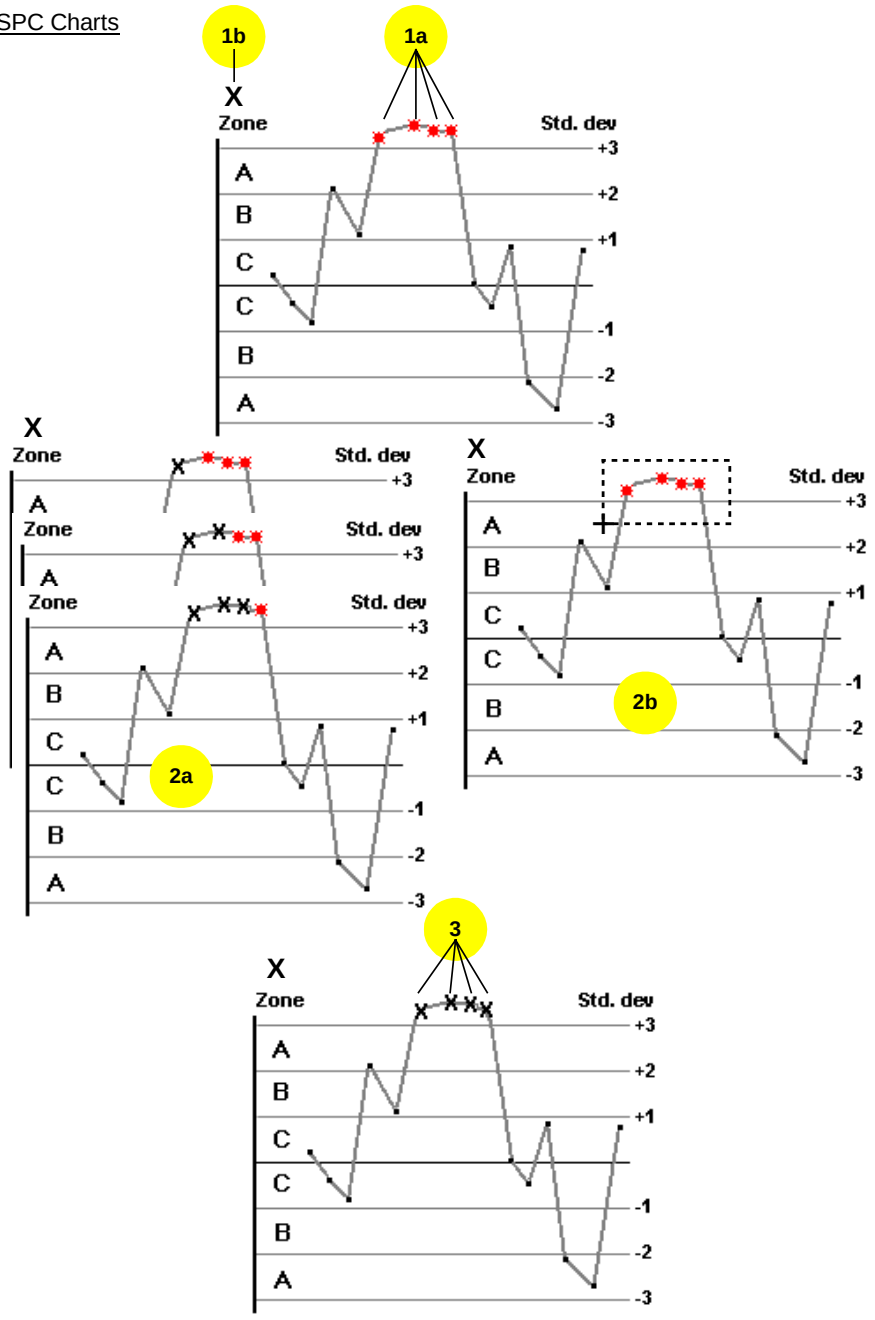
To exlude the samples:

2a Click each dot.
Each dot changes to an X

or

2b Hold down the left mouse button.
Draw a box around the samples.

3 Four Xs (3) represent the samples that are excluded from calculation.



Application Engineering Note: The GetControlLimits() ActiveX method provides access to the control limits displayed on the chart.

Attribute Quality Characteristics

In additional to defining variable quality characteristics, you now have the option of the defining attribute quality characteristics for your product. SPC uses information that you enter in the Attribute Quality Characteristics Properties dialog box to configure in detail p, nP, c and u chart sets.

Use the Attribute Quality Characteristics Properties dialog box to create and define characteristics as follows:

- **General characteristics**—including the name of the characteristic; whether or not data is to be collected for the attribute; whether you want to use a p, nP, c or u chart set.
- **Collection characteristics**—specifies the data collection method.
- **Limits**—sets control and specification limits.
- **Alarms**—indicates alarming and control tests to be performed on the data.

Caution: If you enter specific values during configuration and an inconsistency is detected, SPC will display an error message. You cannot save the configured data until the error is corrected.

Note: If you use Points for general characteristics on limits rather than specific values, SPC will alert the user when the values become specific at runtime. If SPC detects configuration inconsistencies, it will display an $SPC_ADMIN_ALARM in the Alarm Viewer. *See "SPC Administration Alarms."*

Adding a New Attribute Quality Characteristic

To add an Attribute Quality Characteristic, do one of the following:

Method 1 – File menu

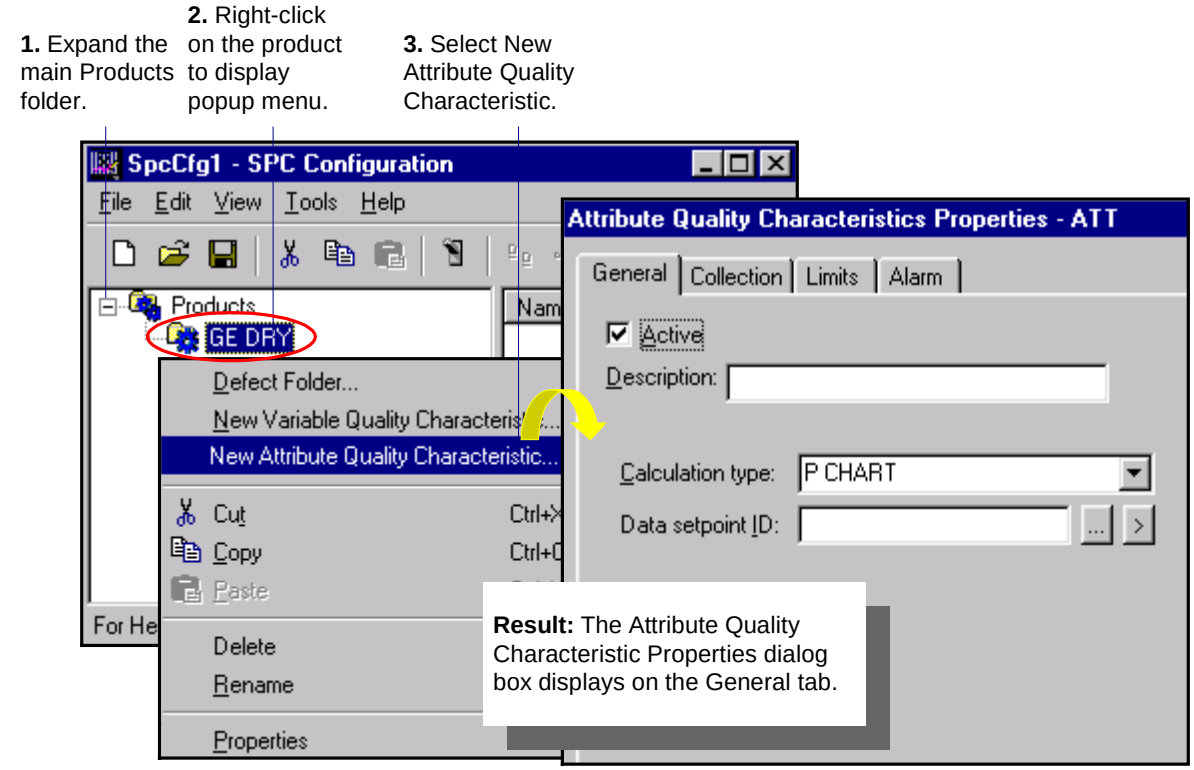
1. Expand the Products folder and select the product.
2. Click File on the menu bar.
3. Select New.
4. Select Attribute Quality Characteristic from the pullout menu.

Method 2 – Popup menu

1. Expand the Products folder and select the product.
2. Right-click and select New Attribute Quality Characteristic from the popup menu.

Result: Using both methods, the Attribute Quality Characteristic Properties dialog box opens with the General tab displayed—see figure.

New Attribute Quality Characteristic - example of right-click method



Specifying an Attribute's General Characteristics

Begin configuring a new attribute by defining its general characteristics in the General tab of the Attributes Quality Characteristics Properties dialog box.

To specify general characteristics:

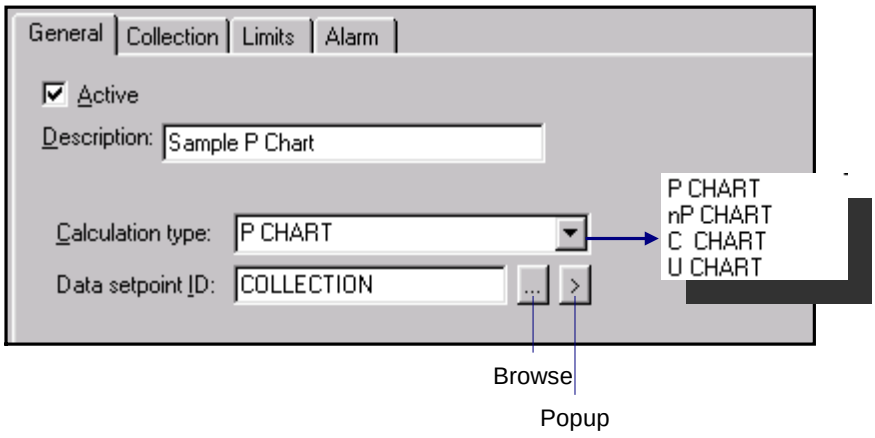
1. Click the General tab—see figure.
2. Check Active box to activate data collection for the attribute; clear box to disable option. The Document and Product must also be active for collection.
3. Type a Description for the attribute that will be displayed in the directory.
4. Select from among p, nP, c and u chart sets from the Calculation type drop-down list.
5. If you want to use the current p, nP, c or u values elsewhere in your project, or download them to a device, indicate the floating-Point in the Setpoint ID field as follows:

   Click [...] to browse for an existing Point in the Select a Point dialog box, or

   Click [>] to designate a New Point.

Note: Of the four available chart types, only one can be configured for a single product at a time. A maximum of four charts can be configured per product.

Attributes Properties-General tab



Defining an Attribute's Collection Characteristics

Define the SPC collection method and the source of the attribute input data using the Collection tab in the Attribute Quality Characteristic Properties dialog box.

Collection methods include:

- **Automatic Data Collection:** either Point, Logged or None. The type selected will activate corresponding fields in the dialog box. When you use an Automatic Collection method, you can also use:

  the same data source for multiple attributes (Match Point)

  a batch process (Batch Point ID or Batch Column ID)

- **Point Data Collection**: one or more CIMPLICITY Points are specified, along with start and end indices for array Points, and any engineering unit conversion (default).
- **Logged Data Collection**: retrieves data from an ODBC database table. Define the ODBC data source, table and column names.
- **None:** specify whether or not manual entry will be allowed. Manual entry can be allowed for any type of data collection you choose. SPC automatically includes manual entry when you select None. Select this option to prevent automatic data collection.

Point Collection for an Attribute

You can designate Points for data collection using the Collection tab of the Attribute Quality Characteristics Properties dialog box. Here, the scope of the collection can also be specified.

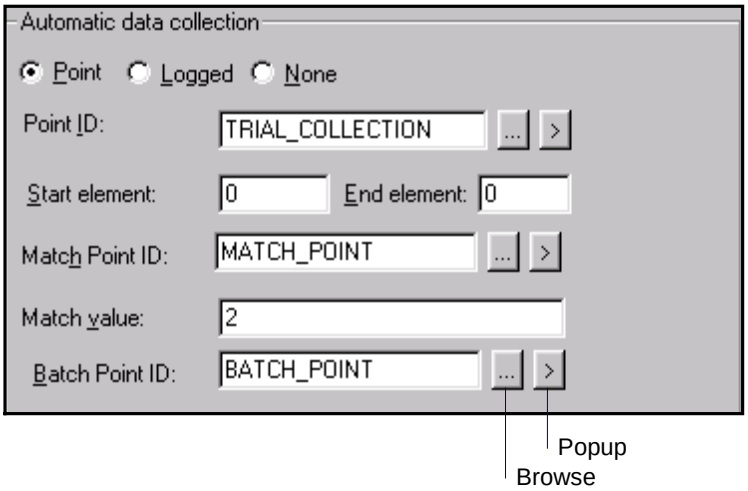
To specify Points for data collection:

1. Click the Collection tab.
2. In the Automatic data collection group, click the Point radio button—see figure.
3. Identify the Point ID (data source) from which the SPC Data Collector retrieves data. The Point ID *cannot* have a Text type. Do one of the following:

   Click [...] to browse for an existing Point in the Select a Point dialog box, or

   Click [>] to designate a New Point.
4. When using any array, specify the number where SPC should begin to collect values in the Start element field. Note that the default is 0.
5. When using any array, specify the number where SPC should finish collecting values in the End element field. Note that the default is 0.

Attribute-Collection Properties-Point



6. Select a Point to indicate the Match Point ID (numeric Point only) in order to use the same data source that is identified by the Point ID for multiple attributes. Do one of the following:

   Click [...] to browse for an existing Point in the Select a Point dialog box, or

   Click [>] to designate a New Point.
7. In the Match value field, enter the value to be matched against the Match Point ID to determine whether the collected data applies to this specific attribute quality characteristic.
8. If this is a batch process, select a Batch Point ID. This will allow you to distinguish between different batches for the same Product Quality Characteristic. The value of

the Batch Point is associated with the calculated data and can be used as search criteria for charts and reports. Do one of the following:

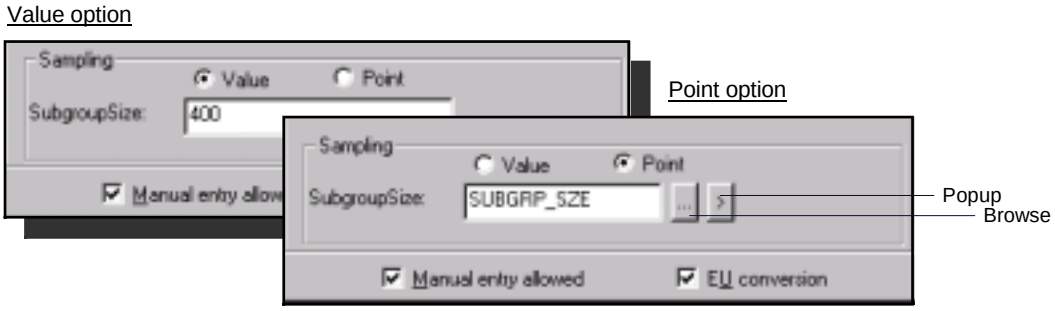
Click [...] to browse for an existing Point in the Select a Point dialog box, or

Click [>] to designate a New Point.

9. Base Sampling parameters on Value or Point by clicking the appropriate radio button.
10. Indicate the Subgroup size (sample) as follows—see figure:
    a. If based on Value, type a value for the sample size, or
    b. If based on Point, do one of the following:

       Click [...] to browse for an existing Point in the Select a Point dialog box, or

       Click [>] to designate a New Point.



11. Check the Manual entry allowed box to enable manual data entry for SPC chart sets at runtime; clear to disable option.
12. Check the EU conversion box if the SPC Data Collector is to use the EU value(s) for the Point. Clear if the SPC Data Collector should use the raw value(s) for the Point

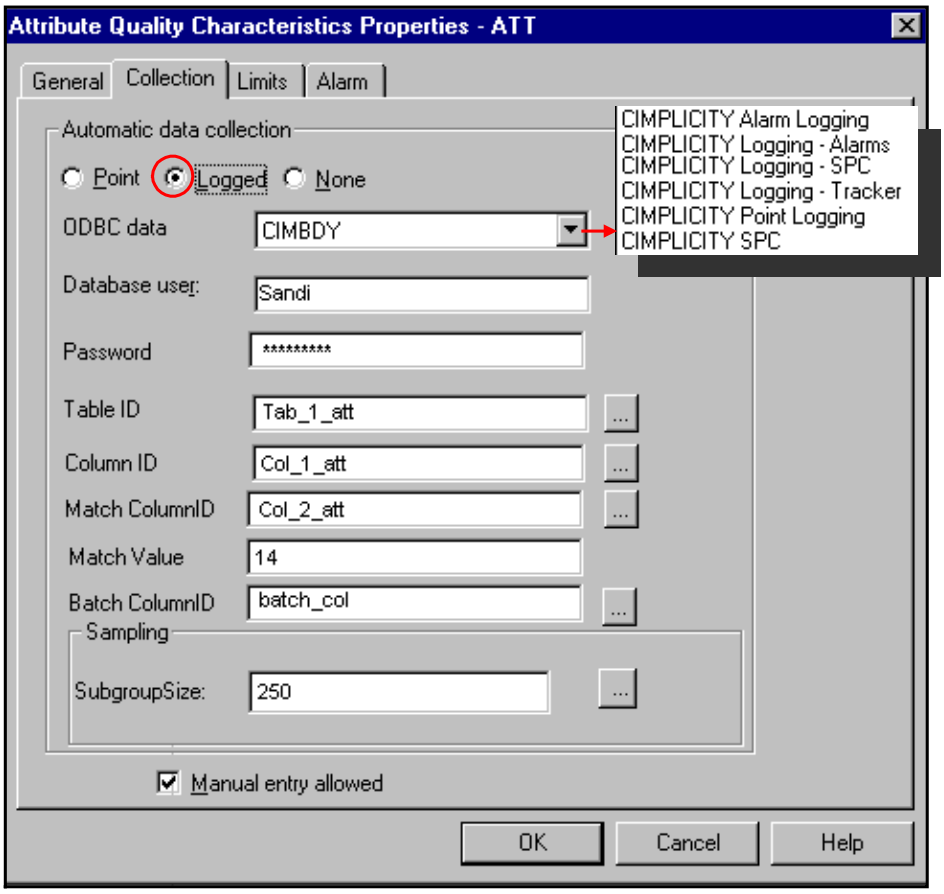
Logged Collection for an Attribute

You can choose to use data logged for the attribute in the ODBC database table that is updated by CIMPLICITY HMI. Specify logged collection options using the Attribute Quality Characteristic Properties dialog box.

To specify Logged for data collection:

1. Click the Collection tab.
2. Click the Logged radio button.
3. Use the ODBC data source drop-down list to select the name of the database from which SPC will retrieve data.
4. In the Database user field, type a name for the user when logging into the ODBC data source.

Attributes-Collection Properties-Logged



5. In the Password field, type a password for the user when logging into the ODBC data source.
6. Click ... to browse for the Table ID where data is located.
7. Click ... to browse for the Column ID where data is located.

8. Click to browse column ID to match against when using the same data source for multiple attributes.
9. In the Match value field, enter a value (integer) to be matched against the Match Column ID to determine whether the collected data applies to this specific attribute quality characteristic.
10. If the process is a batch process, click to browse for the Batch Column ID that will allow you to distinguish between different batches for the same Product Quality Characteristic. The value of the Batch Point is associated with the calculated data and can be used as search criteria for charts and reports.
11. Indicate the Subgroup size as follows:

    Enter a numeric value, or

    Click to browse for the column where the subgroup size is located.
12. Check the Manual entry allowed box to enable manual data entry for SPC chart sets at runtime; clear to disable option.

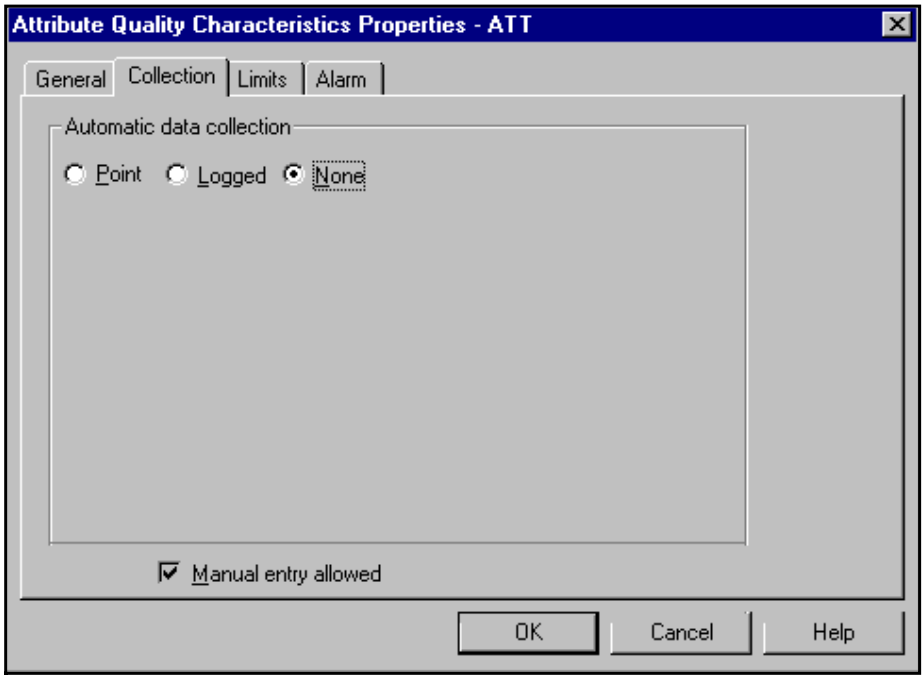
No Collection for an Attribute

If you choose to enter your own data, do not designate a data collection source.

To specify None for data collection:

1. Click the Collection tab.
2. Click the None radio button.

Result: The Manual entry allowed box is checked by default to enable manual data entry.



Setting Limits for Attribute Quality Characteristics

Once you have defined the attribute's general characteristics and collection methods, you are ready to set control limits for your p, nP, c and u chart sets in the Attributes Quality Characteristics Properties dialog box.

Included are:

- Control limits, and
- Specification limits.

Control Limits for an Attribute

In order to set control limits for your chart sets, SPC provides you with several different options. If you know the limits that you want to set, you can use Points or Values. If the process is new and you would like to have limits calculated automatically for you, you can use the auto recalculation features. Whatever your preference, SPC provides you with an option.

You can specify values for control limits by:

- entering values, or
- using auto recalculation.

You can enter values as:

- (specific) values
- Points

Caution: If you enter specific values during configuration and SPC detects an inconsistency, it will display an error message and will not allow you to save the configuration until you correct the error.

Example

You select Values to enter an attribute's control limits and enter 25 for an Upper Control Limit and 50 for a Lower Control Limit. SPC will display the following error message, "The upper control limit must be greater than the center line and the center line must be greater than the lower control limit."

Note: If you use Points for general characteristics on limits rather than specific values, SPC will alert the user when the values become specific at runtime. If SPC detects configuration inconsistencies, it will display an $SPC_ADMIN_ALARM in the Alarm Viewer. *See "SPC Administration Alarms."*

SPC Auto Recalculation Feature

One of the many advantages SPC offers is its ability to automatically calculate the control limits for a process. This is an excellent feature when your process is new and you want the SPC program to generate control limits.

SPC offers two options to automatically recalculate control limits:

- Auto recalculation: is used in place of Values or Points. Once the control limits are automatically calculated, select either Values or Points for the life of the process.
- Force Auto Recalc: is used in addition to Values or Points. This option provides the flexibility to reset control limits during runtime. As a result, when you send an application to production, you can have SPC recalculate the control limits so that they are accurate for the process. Once the control limits are automatically calculated, deactivate the Force Auto Recalc option.

Important: The Quality Control rules you have always followed for control limits still apply to both SPC automatic recalculation options, as follows:

- When your process is new or in optimum condition, calculate the limits using the Auto Recalculation or Force Auto Recalculation option.
- Once you determine that SPC has automatically collected enough data to calculate the correct control limits, disable the automatic collection option.
- The calculated control limits are then used for the life of the process.
- Remember that the control limits produced by auto recalculation are valid only when your process is "in control." If you calculate them while your process is going "out of control," then the limits will be incorrect.

Control Limits for (Specific) Values

You can use your own criteria to set control limits using the Values option in the Limits tab of the Properties dialog box. Also, you can use the Force Auto Recalc feature to override limit values set in the dialog box.

To specify values for control limits:

1. Click the Limits tab.
2. Click the Values radio button—see figure.
3. Enter the values for the p, nP, c or u chart's control limits as follows:

   UCL—Upper control limit.

   CL—Center line.

   LCL—Lower control limit.

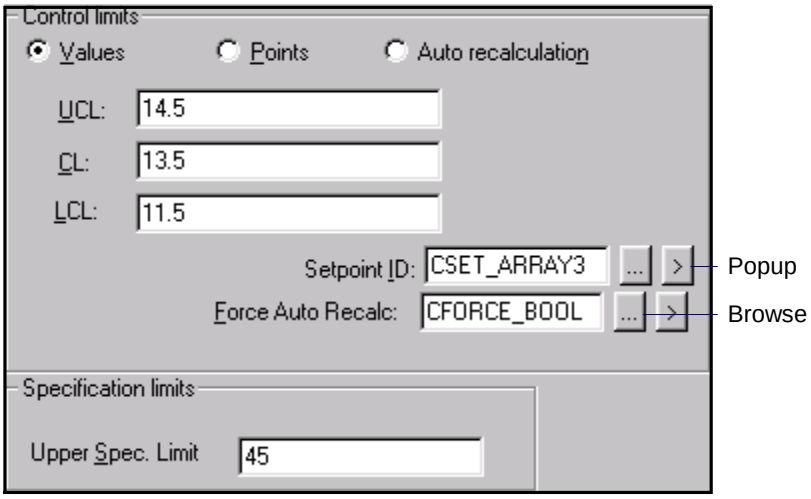
4. If you want to use the current control limits elsewhere in your project, or download them to a device, indicate the floating-point array Point of three (3) elements in the Setpoint ID field. The Point contains three elements for all values to be set in the following order: LCL, CL, UCL. Do one of the following:

   Click ... to browse for an existing Point in the Select a Point dialog box, or

   Click > to designate a New Point.

5. Indicate the Upper Spec Limit for control criteria.

Attributes-Limits Properties-Values



To use auto recalculation to set control limit values:

- In the Force auto recalc field, indicate the Boolean Point ID that has been created to override the value control limits at runtime. This feature can be configured to be turned on or off at runtime.
  Point On
  When the Point is on (set to TRUE), auto recalculation is activated and the chart's control limits are recalculated. Pre-set values are ignored.
  Point Off
  When the Point is off (set to FALSE), auto recalculation is deactivated and the last calculated values are used. Pre-set values are ignored until the data collector is restarted or dynamically refreshed.

  Do one of the following—see figure:

  Click ... to browse for an existing Point in the Select a Point dialog box, or

  Click > to designate a New Point.

Note: Whenever the Force Auto Recalc Point is set to either TRUE or FALSE, the data collector will drop the current sample and start fresh.

Points Control Limits

In order to use Points to set control limit criteria, use the Points option in the Limits tab of the Properties dialog box. Also, you can use the Force Auto Recalc feature to set the Point values for control limits.

To specify Points for control limits:

1. Click the Limits tab.
2. Click the Points radio button—see figure.
3. Enter the a different Point for the UCL, CL and LCL control limits as follows:

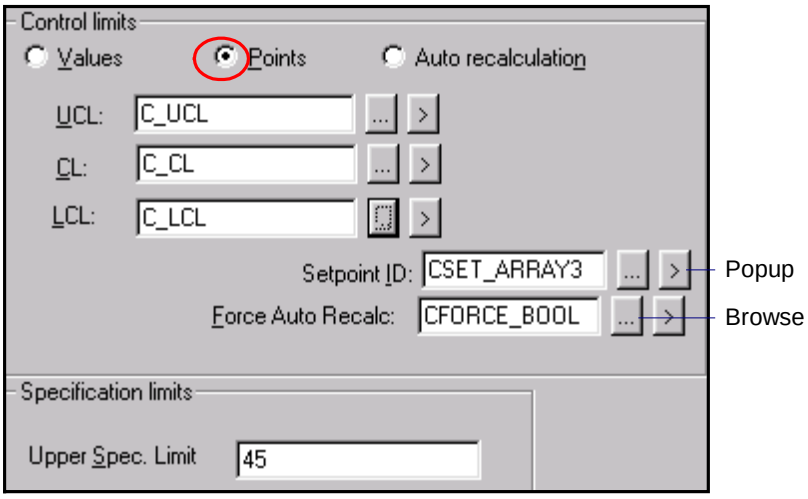
   Click [...] to browse for an existing Point in the Select a Point dialog box, or

   Click [>] to designate a New Point.
4. If you want to use the current control limits elsewhere in your project, or download them to a device, indicate the floating-point array Point of three (3) elements in the Setpoint ID field. The Point contains three elements for all values to be set in the following order: LCL, CL, UCL. Do one of the following:

   Click [...] to browse for an existing Point in the Select a Point dialog box, or

   Click [>] to designate a New Point.
5. Indicate the Upper Spec Limit for control criteria.

Attributes-Limits Properties-Points



To use auto recalculation to set Point values:

- In the Force auto recalc field, indicate the Boolean Point ID that has been created to override the value control limits at runtime. This feature can be configured to be turned on or off at runtime.

  Point On
  When the Point is on (set to TRUE), auto recalculation is activated and the chart's control limits are recalculated. The data collector will set the control Points (specified in the dialog box fields) to the calculated values.

  Point Off
  When the Point is off (set to FALSE), auto recalculation is deactivated and the last calculated values are used until the control Points are updated.

  Do one of the following—see figure:

  Click to browse for an existing Point in the Select a Point dialog box, or

  Click to designate a New Point.

Note: Whenever the Force Auto Recalc Point is set to either TRUE or FALSE, the data collector will drop the current sample and start fresh.

Auto Recalculation Control Limits

In order to automatically set control limits for a new process, or when your process is in optimum condition, use the Auto Recalculation option.

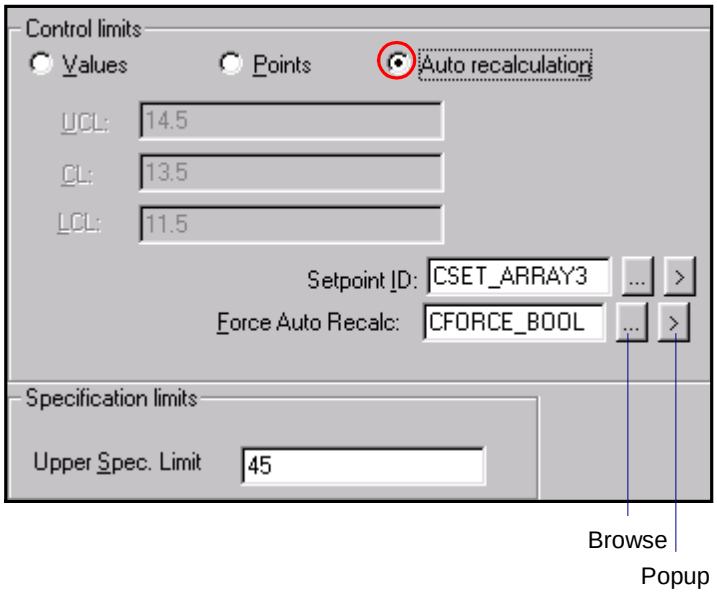
To use auto recalculation to automatically set values:

1. Click the Limits tab.
2. Click the Auto recalculation radio button—see figure.
3. If you want to use the current control limits elsewhere in your project, or download them to a device, indicate the floating-point array Point of three (3) elements in the Setpoint ID field. The Point contains three elements for all values to be set in the following order: LCL, CL, UCL. Do one of the following:

   Click [...] to browse for an existing Point in the Select a Point dialog box, or

   Click [>] to designate a New Point.

Attributes-Limits Properties-Auto recalculation



4. In the Force auto recalc field, indicate the Boolean Point ID that has been created to override the value control limits at runtime. This feature can be configured to be turned on or off at runtime.

   Point On

   When the Point is on (set to TRUE), auto recalculation is activated and all previous values are ignored.

   Point Off

   When the Point is off (set to FALSE), auto recalculation is deactivated and the data collector continues to use the last calculated values.

   Once enough data has been collected to calculate valid control limits, deactivate auto recalculation and use Values or Points to set control limits for your process in the dialog box.

   Do one of the following:

Click to browse for an existing Point in the Select a Point dialog box, or

Click to designate a New Point.

5. Indicate the Upper Spec Limit for analysis.

Note: Whenever the Force Auto Recalc Point is set to either TRUE or FALSE, the data collector will drop the current sample and start fresh.

Setting Alarms for Attribute Quality Characteristics

You can use Alarm settings to warn you if a particular process is slightly off, even when production has not exceeded its control limits on a regular basis. This enables you to anticipate and handle potential problem areas in your production facility.

Use the Alarm tab in the Attribute Quality Characteristics Properties box to specify the:

- type of alarm that will be triggered.
- Setpoint ID.
- control test criteria that will initiate alarms or change Setpoints.

Alarms and Setpoints

When one of the control tests meets your criteria for issuing a warning, it will generate the type of warning you configure, including:

- an alarm to alert operators that criteria have been met for one of the control tests.

  If alarms are generated for more than one control test, they will stack up and be deleted according to specifications you enter in the CIMPLICITY HMI Alarm Configuration.
- a Setpoint that will change to the number (0-9) of the Attribute characteristic tests, alarm state (1-8) and Upper Specification Limit (0). Setpoints provide you with a way to automate corrective action. You can write scripts that trigger the appropriate action whenever the criteria have been met for one of the control tests.

  The value of the Setpoint reflects that last test for which an alarm was triggered.

To specify an alarm and Setpoint:

1. Click the Alarm tab—see figure.
2. You can select the $SPC_ALARM system Alarm ID, or you can create your own alarm in the Alarm ID field. Use the SPC_ALARM type when creating your own alarm. Do one of the following:

   Click to browse for an existing Point in the Select a Point dialog box, or

   Click to designate a New Point.

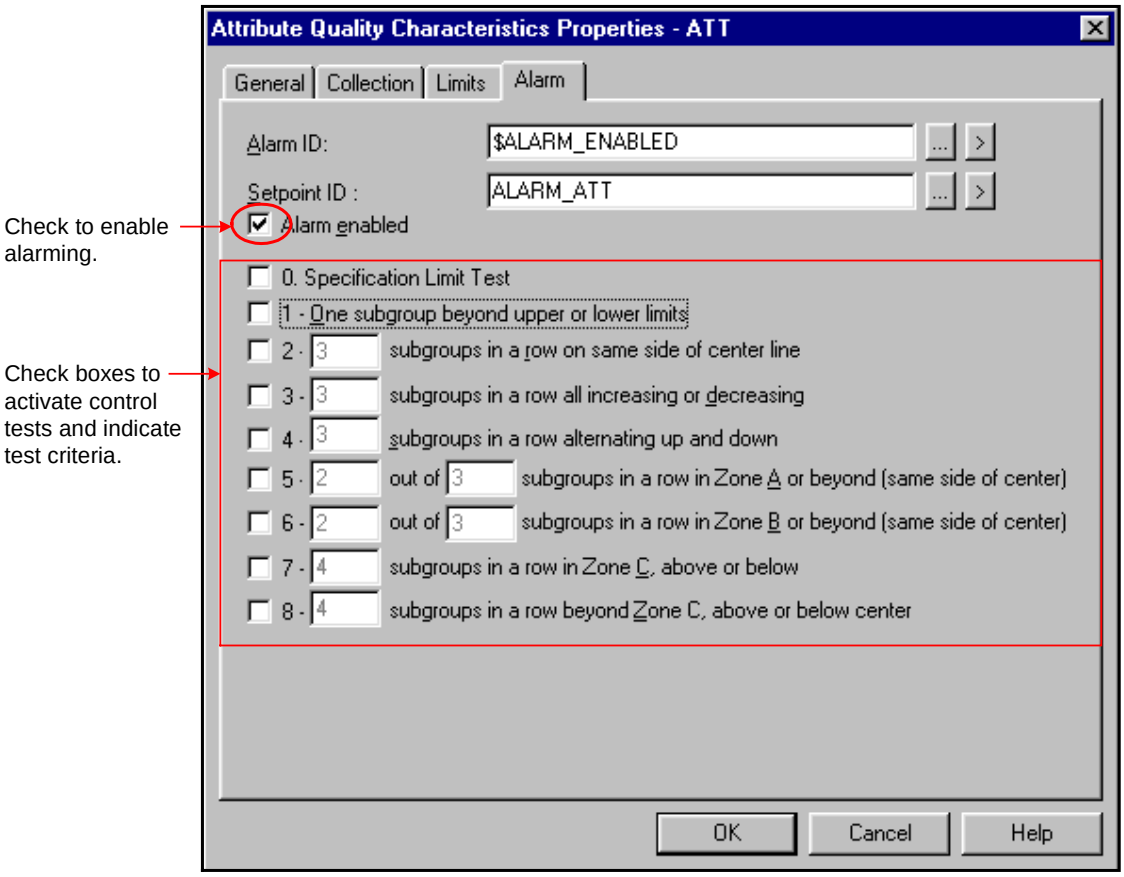
   The alarm message for SPC alarms consists of the following strings:

   - Document Name.
   - Product Name.
   - Quality/Defect Characteristic Name.
   - A description of the control check that triggered the alarm.
   - The value of the sample that triggered the alarm.

3. In the Setpoint ID field, indicate a Point to be set when an SPC alarm occurs. A Setpoint will change to 0-9 of the Attribute QC tests: Alarm state 1-8 and Upper Specification Limit 0. Do one of the following:

   Click ... to browse for an existing Point in the Select a Point dialog box, or

   Click > to designate a New Point.


Attribute Quality Characteristics Properties - ATT
General
Collection
Limits
Alarm
Alarm ID:
$ALARM_ENABLED
Setpoint ID :
ALARM_ATT
Alarm enabled
0. Specification Limit Test
1 - One subgroup beyond upper or lower limits
2 - 3 subgroups in a row on same side of center line
3 - 3 subgroups in a row all increasing or decreasing
4 - 3 subgroups in a row alternating up and down
5 - 2 out of 3 subgroups in a row in Zone A or beyond (same side of center)
6 - 2 out of 3 subgroups in a row in Zone B or beyond (same side of center)
7 - 4 subgroups in a row in Zone C, above or below
8 - 4 subgroups in a row beyond Zone C, above or below center
OK
Cancel
Help
Check to enable alarming.
Check boxes to activate control tests and indicate test criteria.

4. Check the Alarm enabled box to activate alarming for the attribute; clear to disable option.
5. Proceed to next section, *"Criteria for Attribute Control Tests,"* for complete instructions and information.

Criteria for Attribute Control Tests

SPC plots the averages of the samples you define on n, nP, c and u chart sets. These charts will display the zones in which these averages fall. At runtime, each subgroup that does not meet one or more of the selected tests will be displayed with a special character (the default is a red asterisk).

The following zones are used in these tests:

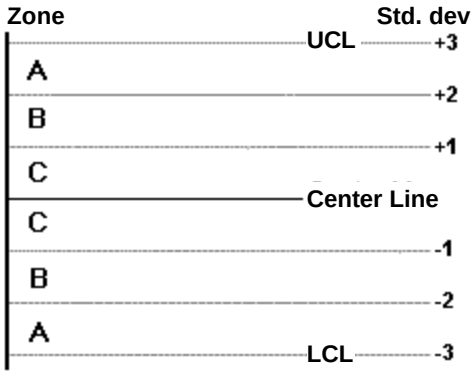
- Zone C is the area up to one standard deviation from the center line.
- Zone B is the area between one and two standard deviations from the center line.
- Zone A is the area between two and three standard deviations from the center line.

Performing multiple control tests:

In the Alarm tab of the Attribute Quality Characteristics Properties dialog box, you can run multiple control tests on your data by checking the appropriate boxes. At runtime, each data value will be compared with all of the selected alarm conditions and plotted on your configured SPC chart. When you position your cursor over the red asterisk (default character), a detailed tool tip will display with the date, time, point value and failed test data, i.e. the control test number(s).

Note: When you create a control chart, you can select samples for exclusion. *See "SPC Control Test Exclusion Mode" for instructions.*

The following example depicts the standard:



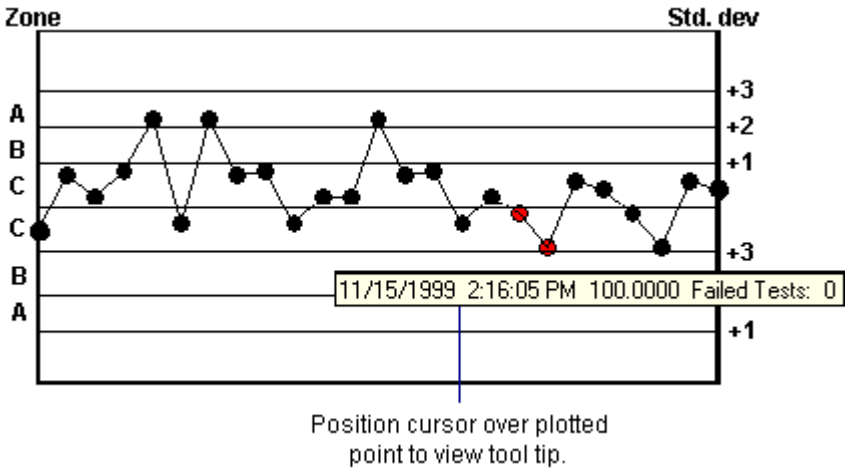
To perform attribute control tests:

1. Check the appropriate box in the Alarms tab for each of the tests to be performed.
2. View test results by:
   - accessing a configured SPC chart to view runtime data, or
   - configuring a new SPC chart.

Control Test 0: Specification limit test

This test checks the calculated acceptable percentage of nonconforming units or defects to the total sample size. Subgroups that meet test criteria will be marked with a red asterisk.

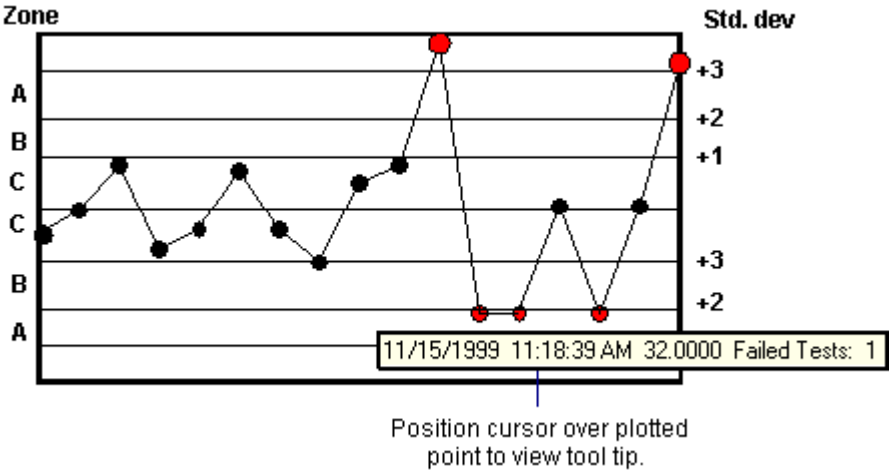
For example, if UCL = 10,



Control Test 1: One subgroup beyond upper or lower limits

This test checks to see if any subgroups on the chart have a value greater than the upper control limit or less than the lower control limit. Subgroups that meet test criteria will be marked with a red asterisk.

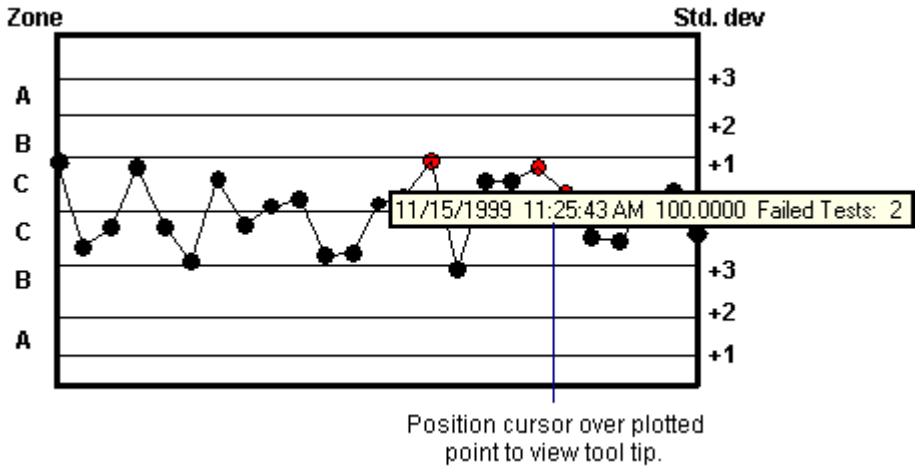
For example:



Control Test 2: N subgroups in a row on same side of center line

This test checks to see if N subgroups in a row are on the same side of the center line. The Nth subgroup and all following subgroups that meet the test criteria will be marked with a red asterisk.

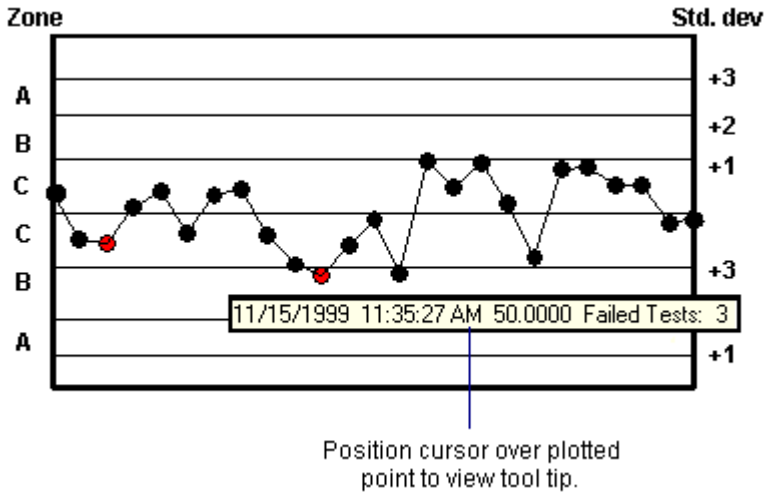
For example, if N=3:



Control Test 3: N consecutive subgroups in a row all increasing or decreasing

This test checks to see if N subgroups in a row are increasing in value or decreasing in value. The Nth subgroup and all following subgroups that meet the test criteria will be marked with a red asterisk.

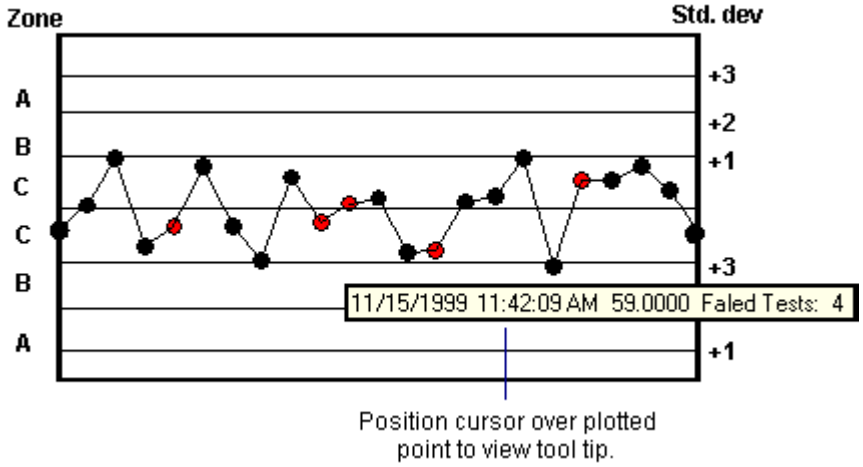
For example, if N=3:



Control Test 4: N subgroups in a row, alternating up and down

This test checks to see if N subgroups in a row are alternately increasing in value then decreasing in value. The Nth subgroup and all following subgroups that meet the test criteria will be marked with a red asterisk.

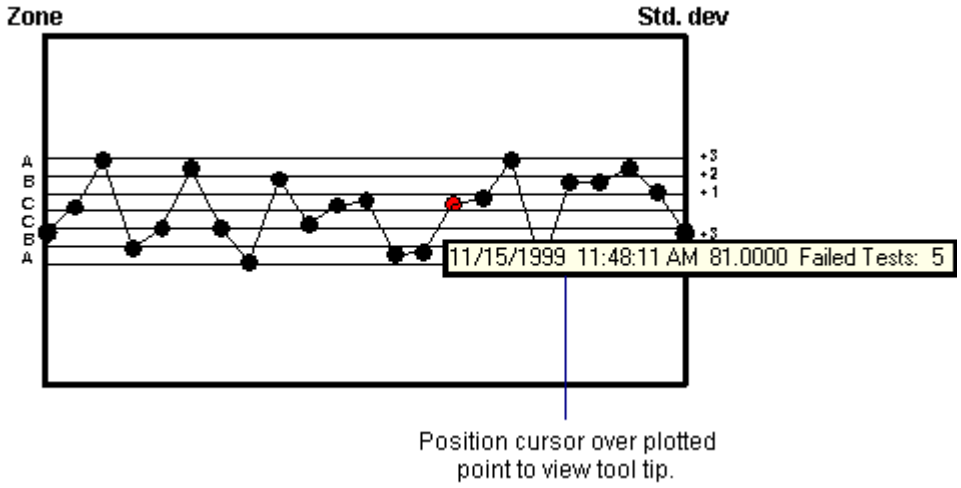
For example, if N=3:



Control Test 5: M out of N subgroups in a row in Zone A or beyond (same side of center)

This test checks to see if M out of N subgroups in a row on the *same* side of the center line are in Zone A or beyond. The Mth subgroup that meets the test criteria will be marked with a red asterisk.

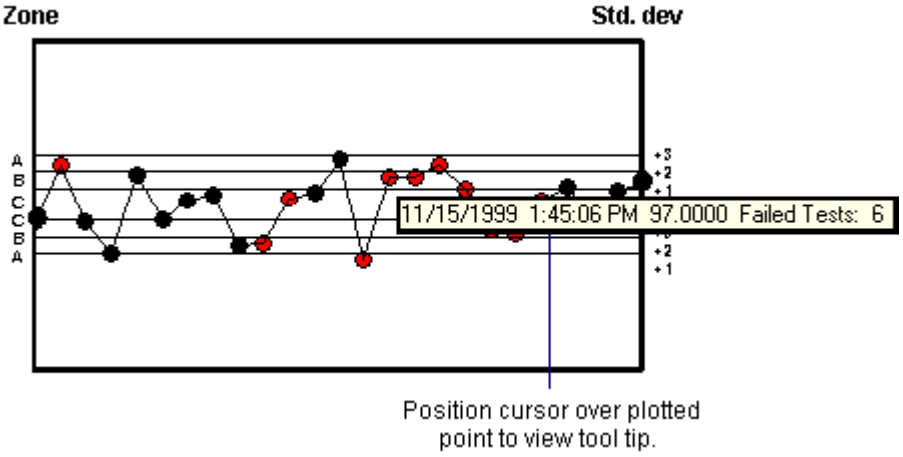
For example, if M=2 and N=3:



Control Test 6: M out of N subgroups in a row in Zone B or beyond (same side of center)

This test checks to see if M out of N subgroups in a row on the *same* side of the center line are in Zone B or beyond. The Mth subgroup that meets the test criteria will be marked with a red asterisk.

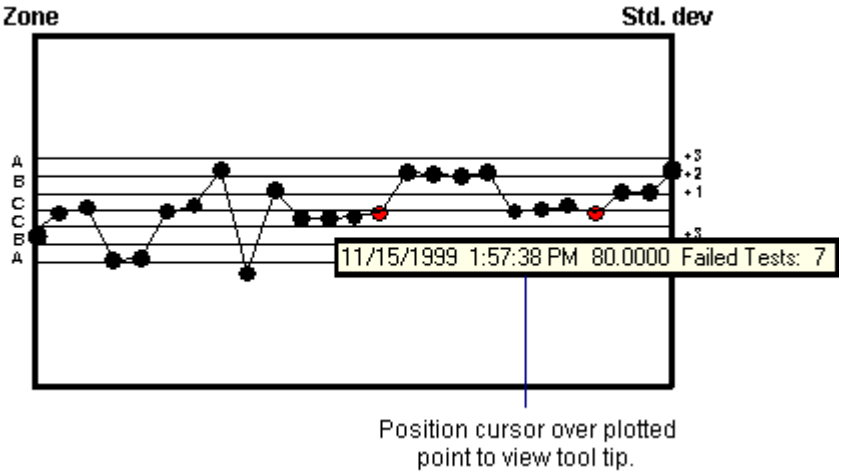
For example, if M=2 and N=3:



Control Test 7: N subgroups in a row in Zone C, above or below center

This test checks to see if N subgroups in a row lie in Zone C on either side of the center line. The Nth subgroup and all the following subgroups that meet the test criteria will be marked with a red asterisk.

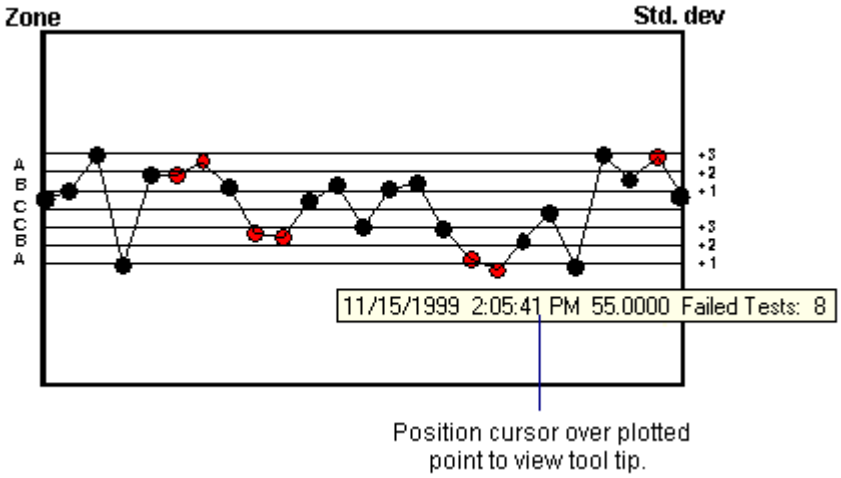
For example, if N=4:



Control Test 8: N subgroups in a row beyond Zone C, above or below center

This test checks to see if N subgroups in a row lie beyond Zone C on either side of the center line. The Nth subgroup and all following subgroups that meet the test criteria will be marked with a red asterisk.

For example, if N=4:



ActiveX

The present ActiveX control is capable of displaying Histograms, X Individual and XBar charts, as well as generating reports for variable QC data. For attribute QC data, p nP, c and u charts can be displayed, as well as generating reports. Pareto charts are available for displaying Defect data. It also handles Manual entry of data for variable, attribute, and defect charts.

You can embed SPC ActiveX objects into any CimEdit screen by inserting and OLE object or by configuring charts using the SPC Properties dialog box.

Defect Folders

In addition to entering product variable and attribute information, you can enter information that SPC will use to track a product's defects. SPC displays each group of defects on a Pareto chart.

Configure defects by:

- creating a Defect folder (will display as a Pareto chart).
- adding defect categories (will each display as one bar on the chart).

Adding a New Defect Group

Within a product, you can create one or more Defect folders for SPC Pareto chart analysis.

To create a Defect folder for a product:

Method 1 – File menu

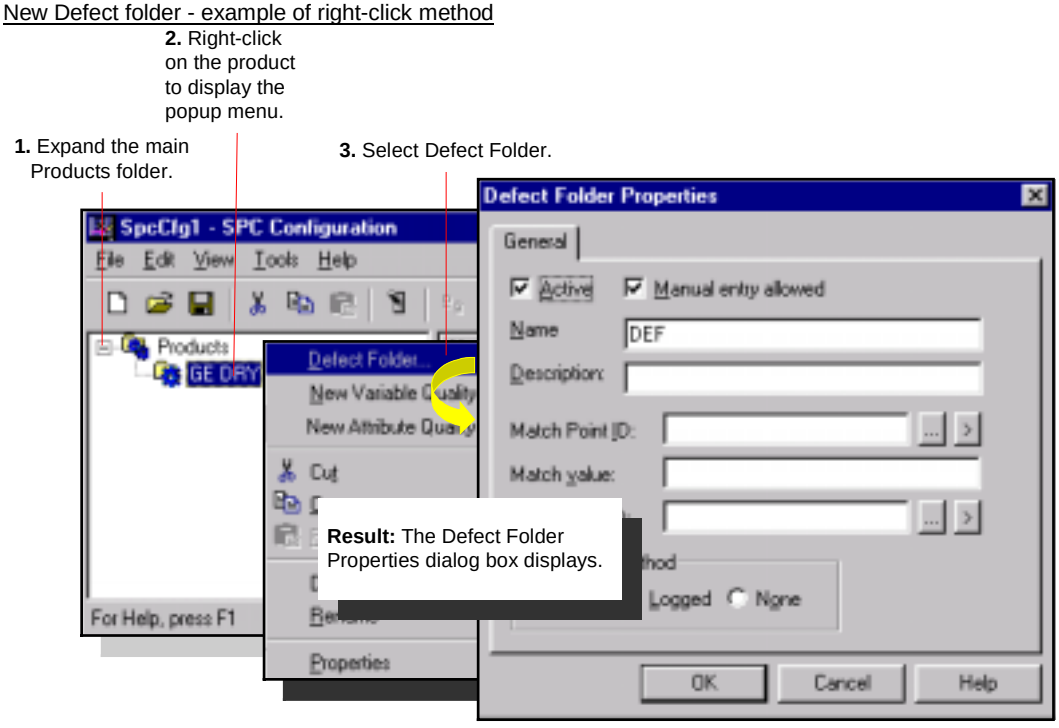
1. Expand the Products folder and select the product in the directory.
2. Click File on the menu bar.
3. Select New.
4. Select Defect Folder from the pullout menu.

Method 2 – Popup menu

1. Expand the Products folder and select the product in the directory.
2. Right-click and select New Defect Folder from the popup menu.

Result: Using either method, the Defect Folder Properties dialog box opens.

New Defect folder - example of right-click method

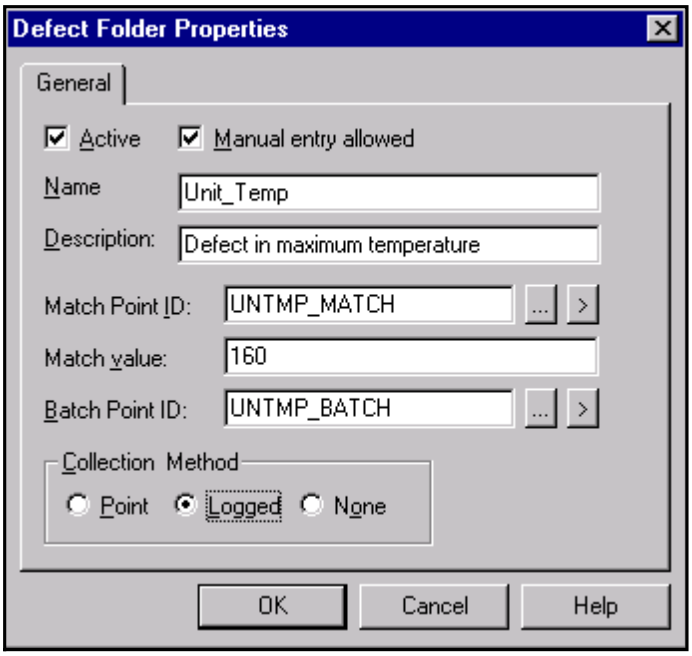


Defining Defect Folder Properties

The Defect Folder Properties dialog box is where you identify each group of Defect Categories that will be included on one Pareto chart. Information you enter here applies to every defect category in the group—see figure.

To define Defect Folder properties:

1. Check Active box to activate data collection for the Defect folder; clear box to disable option. The Document and Product must also be active for collection.
2. Check the Manual entry allowed box to enable manual data entry for SPC chart sets at runtime; clear to disable option.
3. Type a Name for the Defect folder.
4. Type a Description for the Defect folder (optional).



5. Select a Point to indicate the Match Point ID (numeric Point only) in order to use the same data source that is identified by the Point ID for multiple defects. Do one of the following:

   Click ... to browse for an existing Point in the Select a Point dialog box, or

   Click > to designate a New Point.

6. In the Match value field, enter the value to be matched against the Match Point ID to determine whether the collected data applies to this specific defect folder.

   For example, the data source may be used to measure a defect (for example, color) for several products (Product 1, Product 2, Product 3). You can enter a Match Point ID value of 1 to measure color for Product 1, and 2 to measure color for Product 2.

7. If this is a batch process, select a Batch Point ID. This will allow you to distinguish between different batches for the same Product Quality Characteristic. The value of the Batch Point is associated with the calculated data and can be used as search criteria for charts and reports. Do one of the following:

   Click to browse for an existing Point in the Select a Point dialog box, or

   Click to designate a New Point.

8. Click the appropriate radio button to designate the Collection Method, as described below. When adding defect categories to your folder, the method indicated here will determine the corresponding input fields in the Collection tab of the Defect Properties dialog box.

   Point—retrieves data from CIMPLICITY Point values.

   Logged—retrieves data from one or more ODBC database tables.

   None—no data is to be collected by the SPC Data Collector. The Manual entry allowed box is checked by default.

Note: All Defect Categories in this Defect folder will use the collection method you designate for the folder.

Defect Quality Characteristics

Once you have created a Defect folder, add the defect quality characteristics that will appear together, by creating a defect category for each. A bar on the Pareto Chart represents each Defect Category.

Use the Defect Properties dialog box to create and define defects as follows:

- **General characteristics**—Includes the name of the characteristic, and an optional description
- **Collection characteristics**—Describes how the data will be collected. The type of data collection used is determined by the collection method you select for the Defect folder.

Adding a New Defect Category

To place a new Defect Category in a Defect folder, do one of the following:

Method 1 – File menu

1. Select the Defect folder.
2. Click File on the menu bar.
3. Select New.
4. Select Defect Category from the pullout menu.

Method 2 – Popup menu

1. Navigate to the Defect folder in the directory.
2. Select the folder and right-click on it.
3. Select New Defect Category from the popup menu.

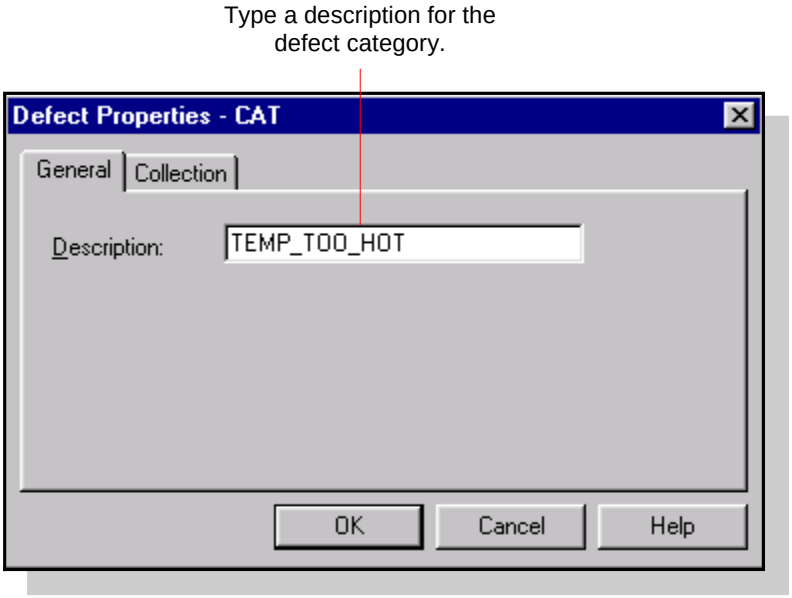
Result: Using either method, the Defect Category Properties dialog box opens defaulted to the General tab.

Specifying a Defect Category's General Characteristics

Begin configuring a new defect category by defining its general characteristics in the General tab of the Defect Properties dialog box. Characteristics are defined when a code is assigned and a description is indicated.

To define general defect characteristics:

1. Click the General tab.
2. Type a text description for the defect in the Description field.



Note: During your configuration and at runtime, if SPC detects configuration inconsistencies, it will display an $SPC_ADMIN_ALARM in the Alarm Viewer. *See "SPC Administration Alarms" in this chapter.*

Defining Defect Category Collection Properties

All Defect Categories in a Defect folder use the same collection method; therefore, specify the collection method in the Defect Folder Properties dialog box. The Collection tab displayed for a Defect Category depends on what you selected for the Defect Folder.

Point Collection for a Defect Category

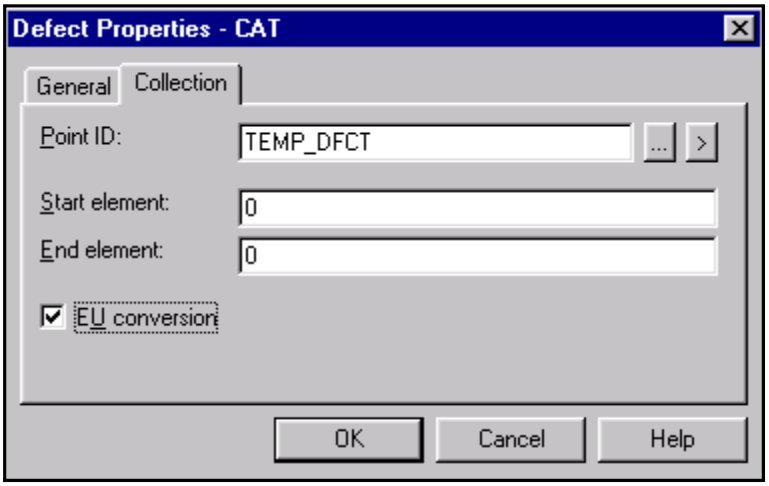
When Point collection is designated in the Defect folder, the Point input fields display in the Defect Properties dialog box—Collection tab.

To specify Point collection for defect:

1. Click the Collection tab—see figure.
2. Identify the Point ID (data source) from which the SPC Data Collector retrieves data. The Point ID *cannot* have a Text type. Do one of the following:

   Click [...] to browse for an existing Point in the Select a Point dialog box, or

   Click [>] to designate a New Point.
3. When using any array, specify the number where SPC should begin to collect values in the Start element field. Note that the default is 0.
4. When using any array, specify the number where SPC should finish collecting values in the End element field. Note that the default is 0.
5. Check the EU conversion box if the SPC Data Collector is to use the EU value(s) for the Point. Clear if the SPC Data Collector should use the raw value(s) for the Point



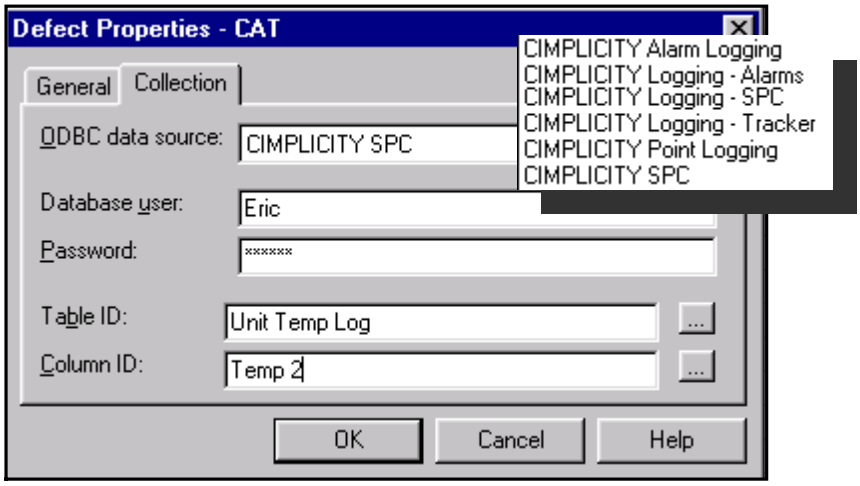
Logged Collection for a Defect Category

When Logged collection is designated in the Defect folder, the Logged input fields display in the Defect Properties dialog box—Collection tab.

To specify Logged collection for defect:

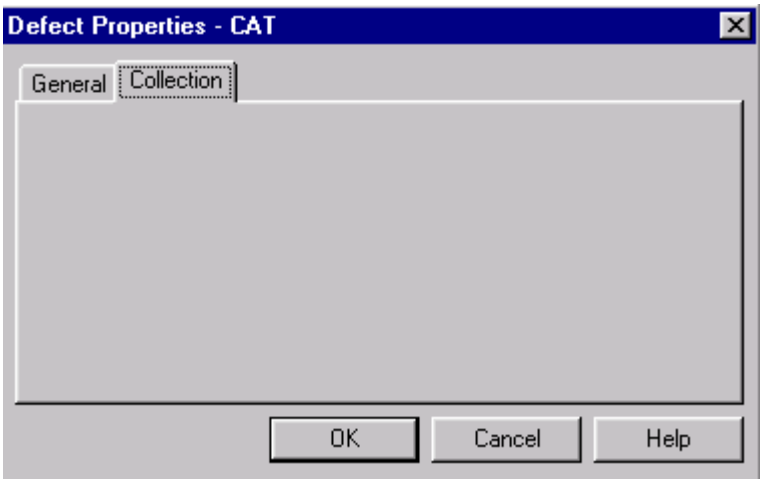
1. Click the Collection tab—see figure.
2. Use the ODBC data source drop-down list to select the name of the database from which SPC will retrieve data.
3. In the Database user field, type a name for the user when logging into the ODBC data source.
4. In the Password field, type a password for the user when logging into the ODBC data source.
5. Click ... to browse for the Table ID where data is located.
6. Click ... to browse for the Column ID where data is located.

Defect Properties dialog box



No Collection for a Defect Category

When no collection method is specified in the Defect folder, there are no applicable input fields in the Collection tab. Manual data entry is automatically enabled.



SPC Administration Alarms

During runtime the SPC application detects the following kinds of inconsistencies:

- Points are unavailable.
- limits are out of sequence.
- sampling parameters are invalid.

Therefore, SPC comes with a built-in $SPC_ADMIN_ALARM to alert operators to those conditions. This alarm is generated because of configuration inconsistencies, in contrast to SPC alarms that are generated because of process problems.

Each instance of this alarm, which will display in your Alarm Viewer, provides you with:

```
\\Group Name\Product Name\QC Name\Alarm number
```

Alarm Numbers are as follows:

1. Required Points(s) are unavailable.
2. XBar control limits are out of sequence.
3. R/S control limits are out of sequence.
4. Sample size is invalid.
5. Gap size is invalid.

Document Tools

The SPC document provides you with three major tools for storing and locating specific information, as follows:

- Document Tree (directory)
- Configure Display Attributes
- Find Function

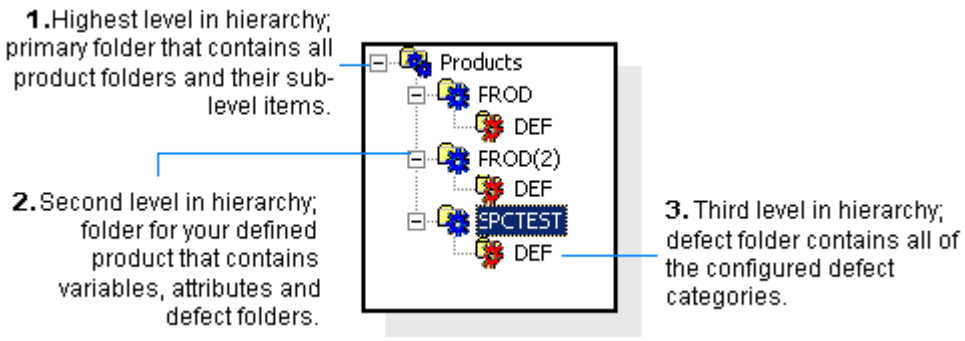
Document Tree

SPC organizes data in a hierarchy that logically emulates the steps you take to configure the application.

1. The Products folder is the primary folder and the top level of the directory hierarchy.
2. Defined Product folders represent the next sublevel in the hierarchy. Contained within the Product subfolder are Variable and Attribute quality characteristics that you configure for your product.
3. Defined Defect folders represent the third level in the hierarchy. Contained within the Defect subfolder are Defect categories that you configure for your product.

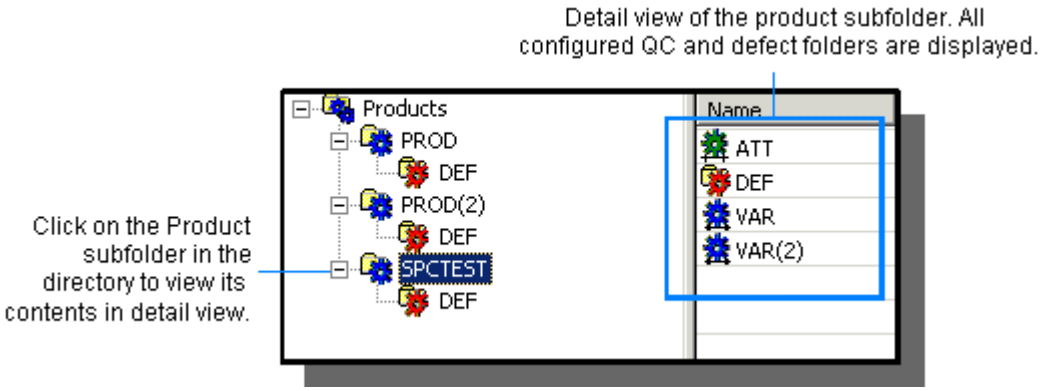
The Main Tree

The directory structure in an SPC document is illustrated below:


1. Highest level in hierarchy; primary folder that contains all product folders and their sub-level items.
2. Second level in hierarchy; folder for your defined product that contains variables, attributes and defect folders.
3. Third level in hierarchy; defect folder contains all of the configured defect categories.
Products
FROD
DEF
FROD(2)
DEF
SPCTEST
DEF

Product Folder in the Document Tree

Each SPC Product folder contains a collection of Variable Quality Characteristics, Attribute Quality Characteristics and Defect folders that can be used to determine the quality of the product. When you click on a Product folder in the directory, the contents of the folder are displayed in the Detail view—see figure:



where:

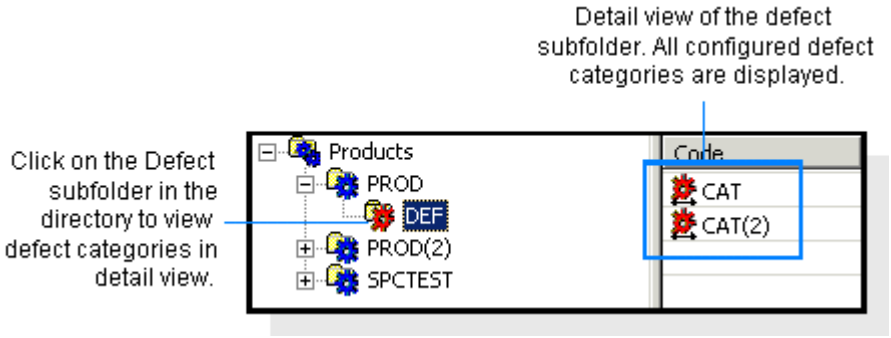
is a Variable Quality Characteristic for the product. Double-click on the applet to view its properties; right-click on the applet to access a popup menu with additional options.

is an Attribute Quality Characteristic for the product. Double-click on the applet to view its properties; right-click on the applet to access a popup menu with additional options.

is a Defect folder for the product that holds configured defect categories. Click on the folder to display its Defect codes in the Detail view.

Defect Folder in the Document Tree

Defect folders contain its configured Defect Categories. When you click on a Defect folder in the directory, the contents of the Details frame look like the following:



where:

is a Defect Category. Double-click on the applet to view its properties; right-click on the applet to access a popup menu with additional options.

Changing Display Attributes

You can change the type of attributes displayed for a QC or defect category, and their order in the detail view of the SPC document using the Configure Display Attributes dialog box. A column will be added to the detail view of the SPC document for each attribute that you choose to display.

To change display attributes, do one of the following:

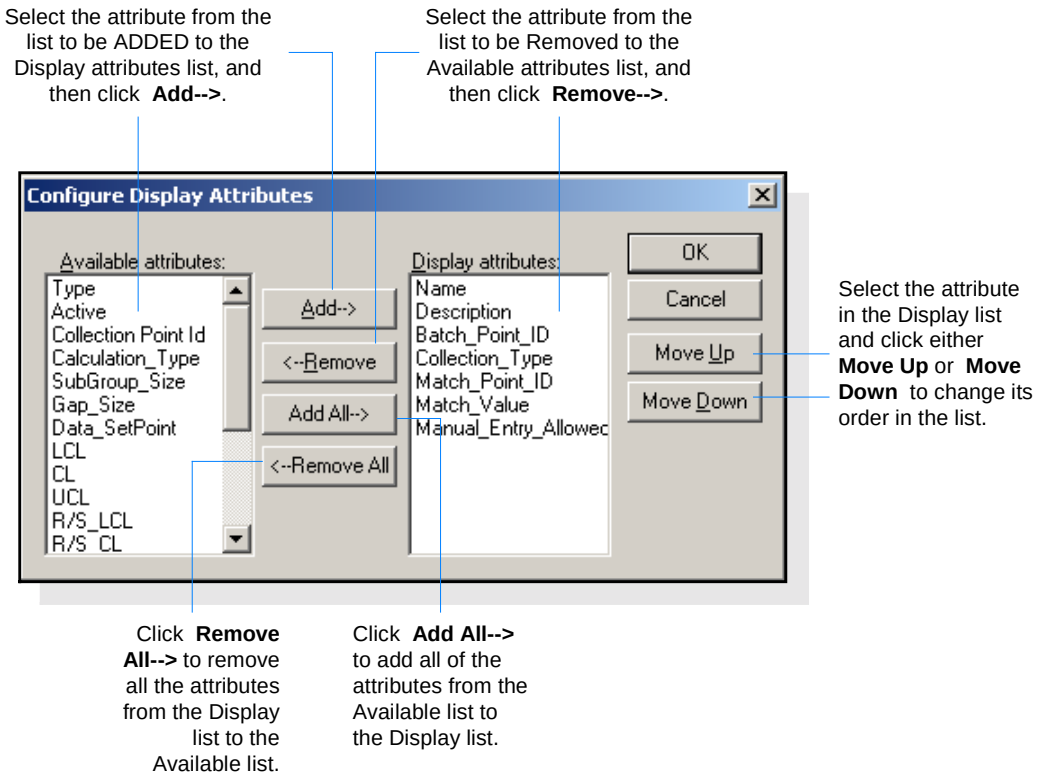
Method 1 – View menu

1. Click View on the menu bar.
2. Select Attributes.

Method 2 – Quick keys

1. Press **Ctrl+A.**

Result: Using either method, the Configure Display Attributes dialog box opens.



The lists are displayed in the dialog box and are described as follows:

- **Available attributes**: list of attributes to choose from for display purposes.
- **Display attributes:** list of attributes in the order in which they are currently being displayed.

Continue from Method 1 or Method 2

1. Add and remove attributes and change their order in the Display list as follows:

To:…	**Then…**
Add one attribute to the Display list,	▪ Select an attribute in the Available attributes list. ▪ Click **Add→**.
Add all attributes to the Display list,	▪ Click **Add All →**.
Remove an attribute from the Display list,	▪ Select the attribute. ▪ Click **Remove→**.
Remove all the attributes from the Display list,	▪ Click **Remove All→**.
Change the order of the attributes in the Display list,	▪ Select the attribute. ▪ Click **Move Up** to move it up in the list. ▪ Click **Move Down** to move it down in the list.

2. Click **OK** to effect changes, or **Cancel** to cancel the operation.

Result: The columns in the detail view display will reflect the selected attributes and their order as defined in the Configure Display Attributes dialog box.

Finding a Product/Quality Characteristic

An SPC document can contain many products and many quality, attribute and defect characteristics. You can use the Find function to quickly search for a specific characteristic or subset of characteristics.

To initiate a search, do one of the following:

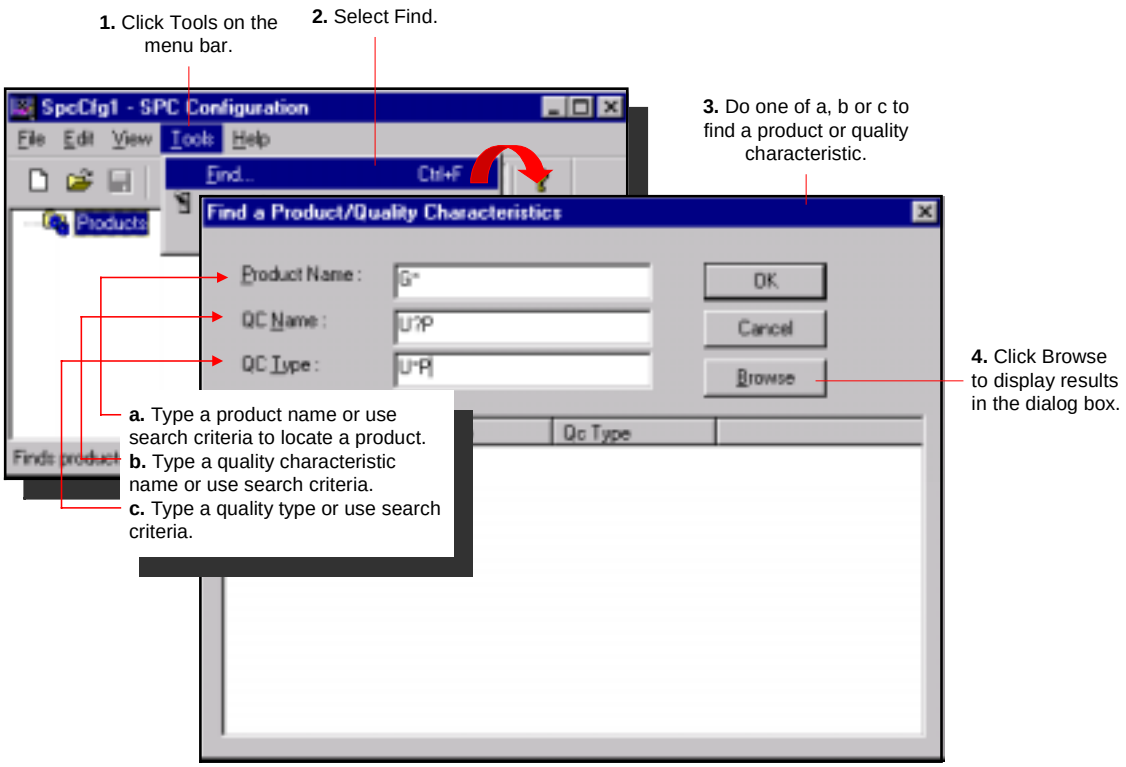
Method 1 – Tools menu

1. Click Tools on the menu bar.
2. Select Find.

Method 2 – Quick keys

1. Press **Ctrl+F**.

Result: Using either method, the Find a Product/Quality Characteristic dialog box opens—see figure.


1. Click Tools on the menu bar.
2. Select Find.
3. Do one of a, b or c to find a product or quality characteristic.
4. Click Browse to display results in the dialog box.
SpcCfg1 - SPC Configuration
File Edit View Tools Help
Find... Ctrl+F
Products
Find a Product/Quality Characteristics
Product Name :
QC Name :
QC Type :
OK
Cancel
Browse
Qc Type
a. Type a product name or use search criteria to locate a product.
b. Type a quality characteristic name or use search criteria.
c. Type a quality type or use search criteria.

Continue from Methods 1&2

1. In the appropriate field, use the following filters to reduce the list of quality and defect characteristics:

   - Product name
   - Quality/Attribute/Defect characteristic name
   - Quality/Attribute/Defect characteristic type

   You can also use wildcards to reduce search results as follows:

   ***** Searches for any number of characters in the string. For example, to display the list of products whose name starts with 'M' and ends with 'X', enter M*X in the Product Name field.

   ? Searches for any number of characters at this Point in the string. For example, to display the list of products that are three characters long, and whose name starts with 'M' and the third character is 'X', enter M?X in the Product Name field.

2. Click **Browse** to display results in dialog box.
3. Double-click the item in the list to go to the item in its folder in the SPC directory—***or***—click **OK** to close the dialog box.

Note: There are no implied wildcards. If you do not include or end your search string with an asterisk, only an exact match will be returned in the result list.

Configuring SPC Charts

Getting Started

After you create your ODBC data source and configure your SPC data collection, you can configure SPC ActiveX controls in CimEdit/CimView screens or other ActiveX containers, such as Internet Explorer, to display your SPC data.

Creating an SPC Chart in CimEdit

To create an SPC chart in a CimEdit screen

Method 1

- Click the **SPC** button on the toolbar.

Result: A new SPC Control is placed in the upper-left corner of the CimEdit screen. The SPC control initially is empty and displays a message for editing the control.

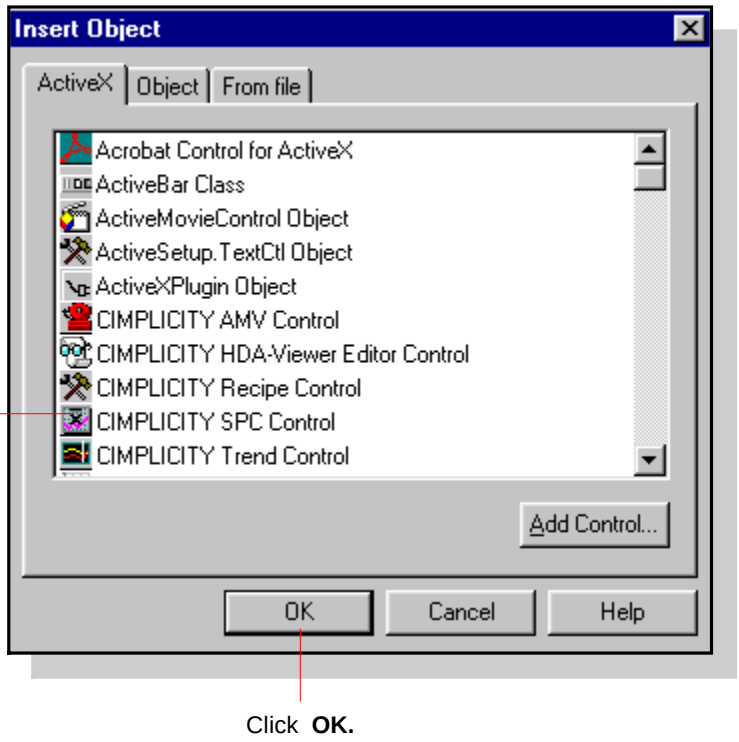
Method 2

1. Click the **OLE** button on the toolbar.

Result: The mouse pointer changes to a bracket **.**

2. Position the bracket on the CimEdit screen and click to fix the position of the chart.

Result: The Insert Object dialog box opens—see figure.



3. Select CIMPLICITY SPC Control from the ActiveX list.
4. Click **OK**.

Result: A new SPC Control is placed at the position you selected in your CimEdit screen. The SPC control initially is empty and displays a message for editing the control.

Configuring SPC Chart Properties

Configure SPC chart Properties using the CIMPLICITY SPC Control Properties dialog box.

To open the CIMPLICITY SPC Control Properties dialog box:

Method 1 – Quickest

- Double-click on the chart.

Method 2 – Edit menu

1. Click Edit on the menu bar.
2. Select CIMPLICITY SPC Control Object.
3. Select Properties from the pullout menu.

Method 3 – Popup menu

1. Select the chart
2. Right-click and select Properties from the popup menu.

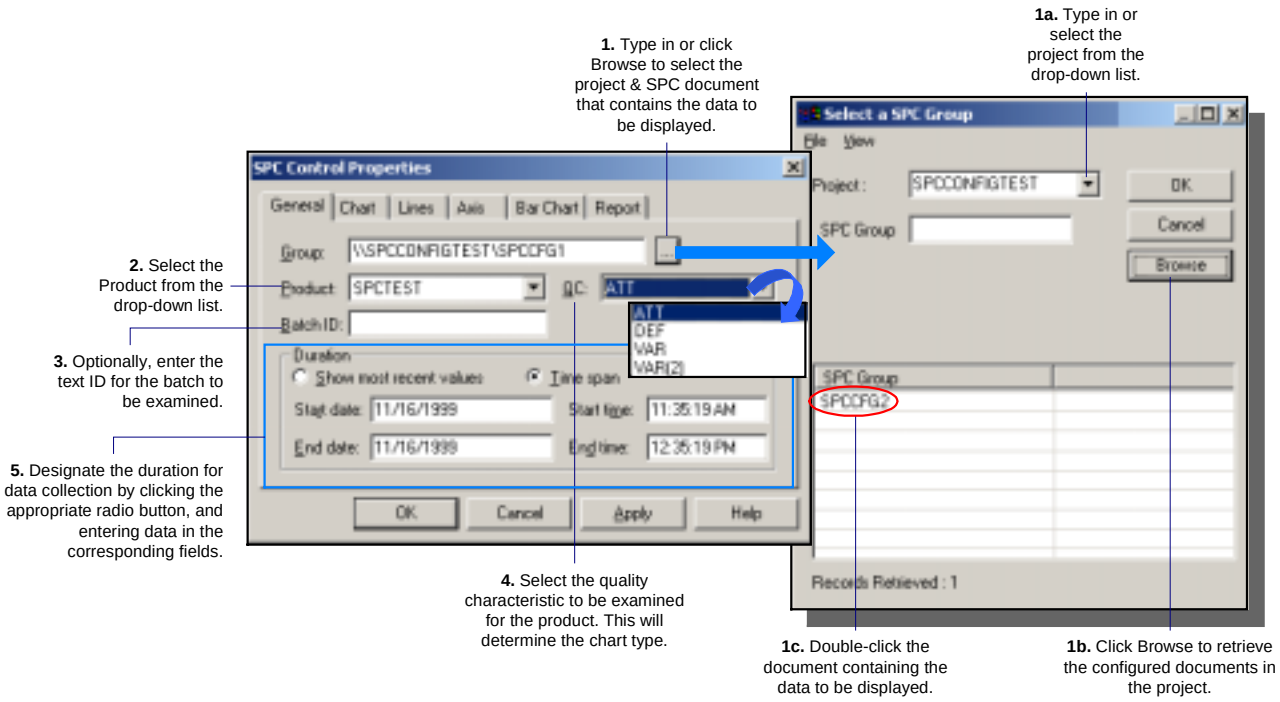
Result: Using any of the above methods, the CIMPLICITY SPC Control Properties dialog box will open.

General Properties

Define the appearance of your SPC chart in the General tab of the SPC Control Properties dialog box—see figure.

To define SPC general properties:

1. Type in the qualified path to the project and SPC document containing the data to be displayed in the chart. Alternately, click the **Browse** button to search for the project and SPC document.
2. Select the Product to be charted from the drop-down list.
3. In the Batch ID field, enter the text that identifies the batch process to be examined. The chart will display only those points where the content of the Batch Point ID matches this identifier.



4. Select the Quality Characteristic (QC) to be examined for the product using the drop-down list. You will have two or more options to choose from based on the calculation for the product and the selected QC: Report and chart type(s).
5. Click the appropriate radio button to select the duration for data collection:
   - Show most recent values—displays the most recent values collected in the chart.
   - Time span—indicate the start time and date and the ending time and date to collect data to be displayed on the chart.

Chart Properties

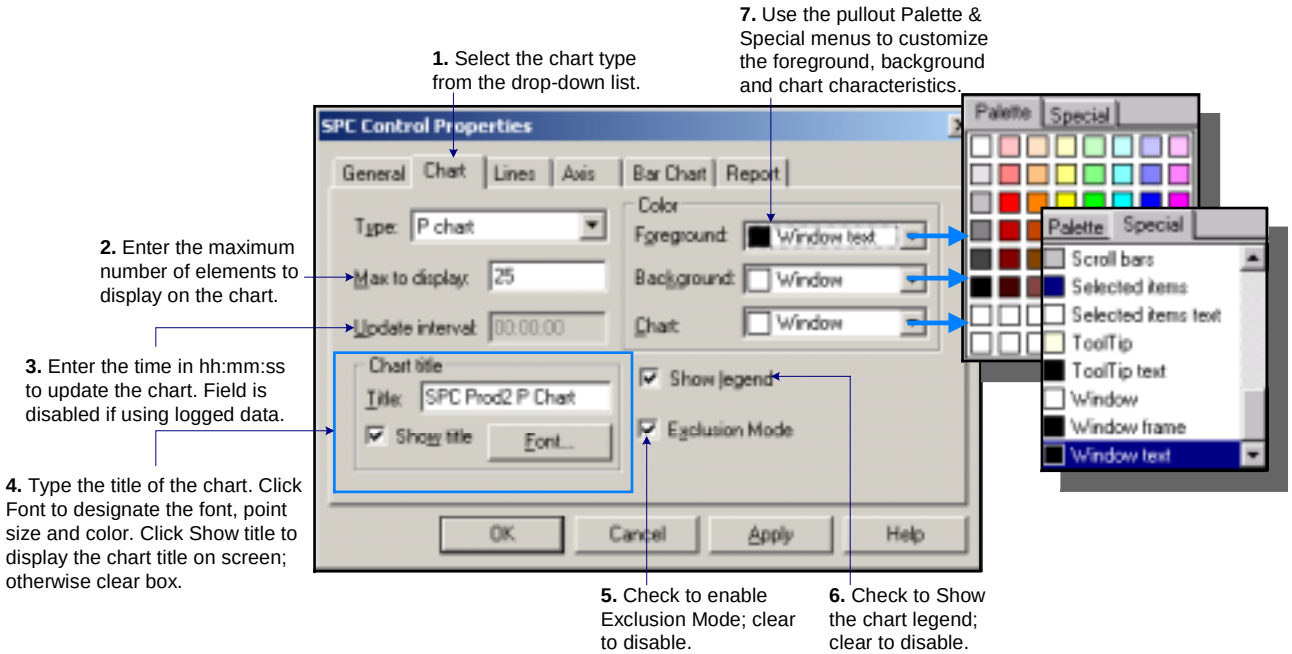
You can choose to display a report or a chart, and you can also customize the look of your display in the SPC Control Properties dialog box—see figure.

To define SPC chart properties:

1. Click the Chart tab.
2. The drop-down list in the Type field will display two or more options: Report and available chart type(s). The chart type is dependent on the QC selected in the General properties and the configuration calculated for the product. The following types may be available in the drop-down list:

Defect QC	Variable QC	Attribute QC
Pareto chart	XBar-R or XBar-S	p
Report	X-Individual	nP
	Report	c
		u
		Report

3. In the Max to display field, type the maximum number of elements to display on the chart using the following guidelines:
   - XBar-R/S charts—number of subgroups.
   - X-Individuals charts, histograms, n, nP, u, c and Pareto charts—number of samples.
4. In the Update Interval field, enter the time in hh:mm:ss to update chart data. Note that this field is disabled if you are using logged data..



5. Type a Title for your report or chart and click the Show title box to display the title on screen.
6. Click **Font** to display the Font dialog box. Adjust the font, style and size of your title using the available options.
7. In the Color group, click the arrows next to Foreground, Background and Chart to display the color Palette and Special options. Select options to customize the display of your report or chart.
8. Click the Show legend box to display legend information on your report or chart. Clear check box to disable.
9. Check Exclusion Mode to enable exclusion mode on your chart. Clear check box to disable.

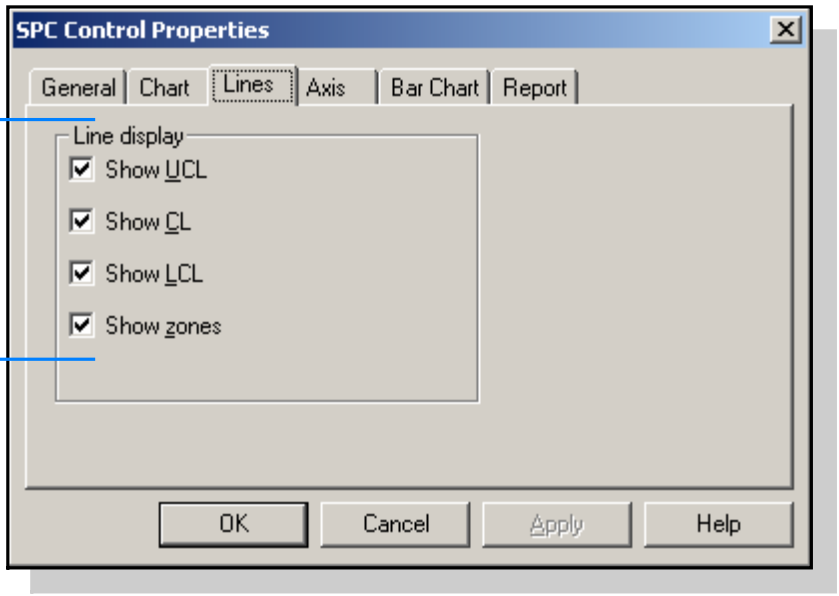
Note: See *"Configuring SPC Data"* for complete information and instructions on Exclusion Mode.

Line Properties

You can choose to display control lines on your chart in the SPC Control Properties dialog box—see figure.

To set line properties:

1. Click the Lines tab.



Check boxes to show lines on your chart. Clear boxes to hide lines.

2. Check boxes to show lines on your chart, or clear boxes to hide lines. Lines display as follows:

Show UCL	Displays upper control limit line.
Show CL	Displays center line.
Show LCL	Displays lower control limit line.
Show zones	Displays zone lines.

Axis Properties

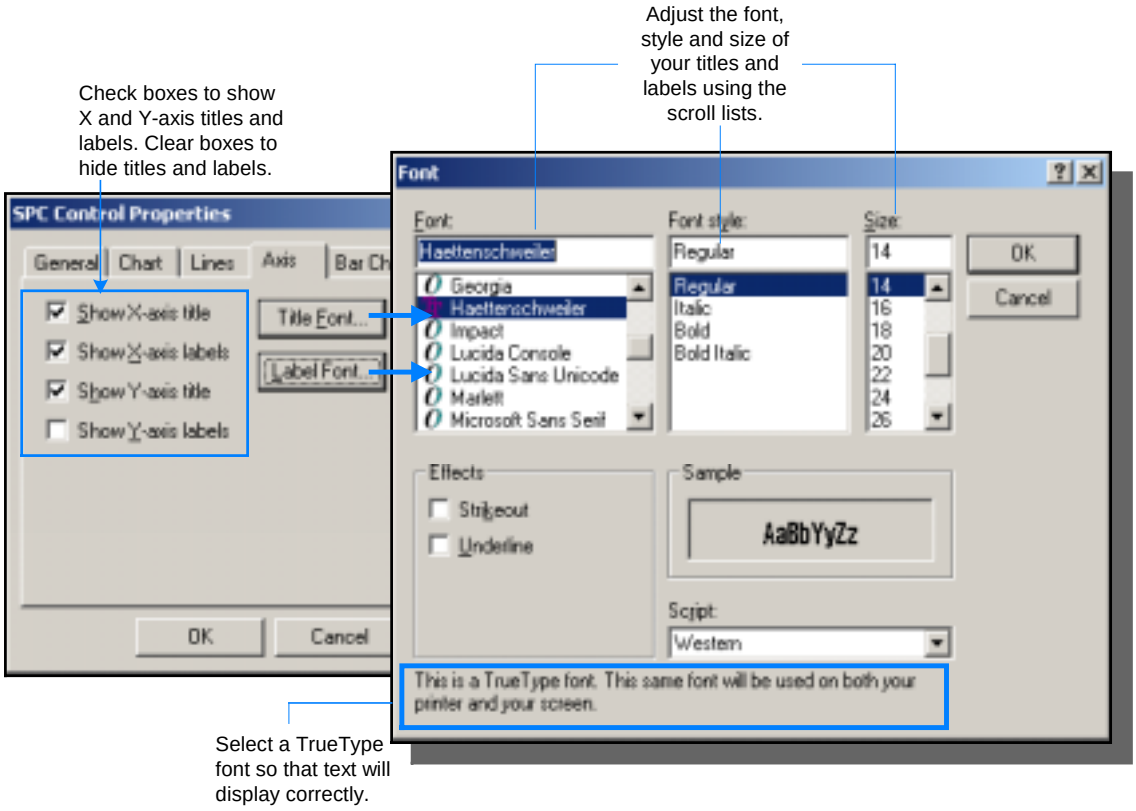
You can choose to display the X and Y-axis of your chart, and also customize the look of their titles and labels in the SPC Control Properties dialog box—see figure.

To set X and Y axis properties:

1. Click the Axis tab.
2. Check boxes to show lines on your chart, or clear boxes to hide lines. Lines display as follows:

Show X-axis title	Displays the X-axis title.
Show X-axis labels	Displays X-axis labels.
Show Y-axis title	Displays Y-axis title.
Show Y-axis labels	Displays Y-axis labels.

3. Click **Font Title** to display the Font dialog box. Adjust the font, style and size of your X and Y-axis titles using the available options.
4. Click **Label Font** to display the Font dialog box. Adjust the font, style and size of your X and Y-axis labels using the available options.



Note: For both the Title and Labels, be sure to select a TrueType font. Other fonts may not display the text correctly on your chart.

Bar Chart Properties

If you are configuring a Histogram or Pareto chart, you can set display parameters in the SPC Control Properties dialog box—see figure. If configuring a report or other chart type, you can skip this section.

To set bar chart properties:

- Click the Bar Chart tab.

Result: If you are configuring a Histogram, the Histogram group will be active in the dialog box and the Pareto group will be dimmed. The reverse is true if you are configuring a Pareto chart.

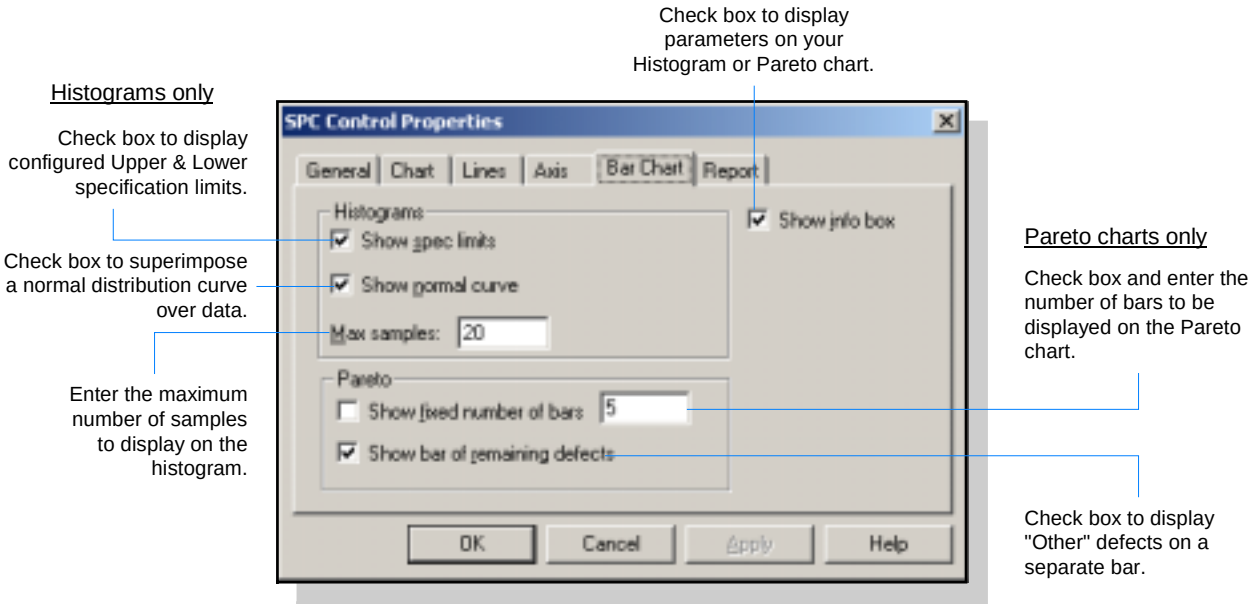
Histograms Group

- Check boxes and enter data using the definitions for options as follows:

  Show spec limits—to display the Upper and Lower Specification Limits configured for the data. Clear check box to disable option.

  Show normal curve—to superimpose a normal distribution curve over the histogram data. Clear check box to disable option.

  Max samples—enter the maximum number of samples to be displayed in the histogram.


Check box to display parameters on your Histogram or Pareto chart.
Histograms only
Check box to display configured Upper & Lower specification limits.
Check box to superimpose a normal distribution curve over data.
Enter the maximum number of samples to display on the histogram.
SPC Control Properties
General
Chart
Lines
Axis
Bar Chart
Report
Histograms
Show spec limits
Show normal curve
Max samples: 20
Show info box
Pareto
Show fixed number of bars 5
Show bar of remaining defects
OK
Cancel
Apply
Help
Pareto charts only
Check box and enter the number of bars to be displayed on the Pareto chart.
Check box to display "Other" defects on a separate bar.

Note: The Histograms and Pareto groups are not both active at the same time on the SPC Control Properties dialog box as shown in the figure above. Figure is for instructive purposes only.

Pareto Group

- Check boxes and enter data using the definitions for options as follows:

  Show fixed number of bars—check box and enter the number of bars to be displayed on the Pareto chart. If you have more defect codes than bars, only the bars for the most frequently occurring defects will display. Clear check box to display a bar for each defect code defined for this product.

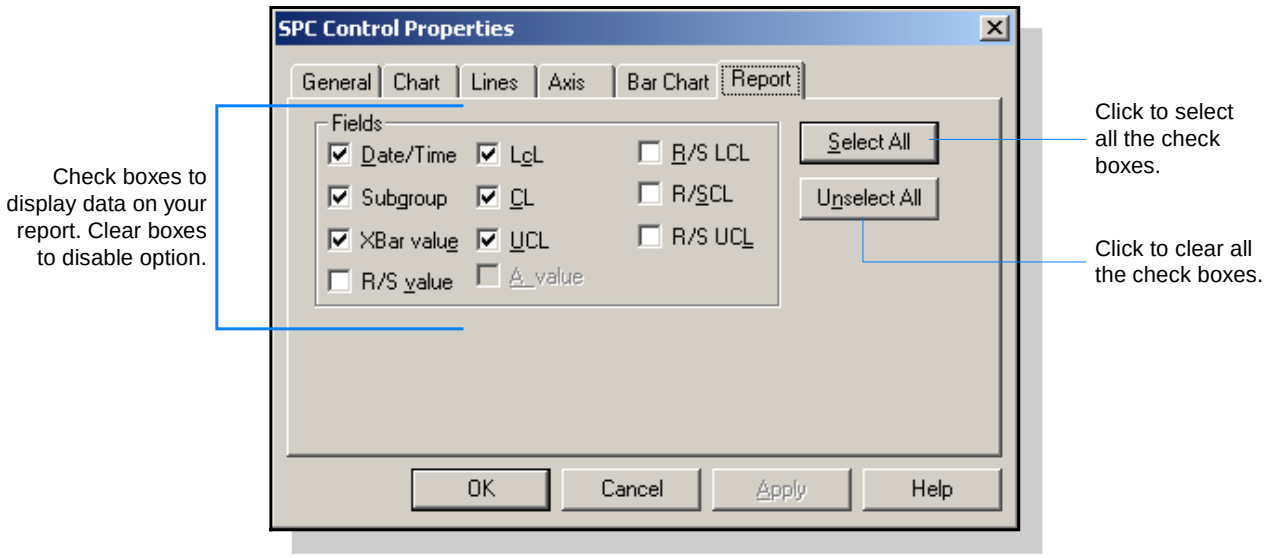
  Show bar of remaining defects—check box to display the total number of other defects on a separate bar marked, "Other." Clear the check box to disable option.

Report Properties

You can configure the data to be displayed on your report in the SPC Control Properties dialog box. Several options for adding information are available using the Report tab—see figure.

To set report properties:

1. Click the Report tab.
2. Check boxes to display options on your report, or clear boxes to disable options.



Tip: Alternately, use the **Select All** button to check all of the options or the **Unselect All** button to disable all of the options.

Creating an SPC Chart in a Web Page

The following is a sample HTML fragment that will display an SPC ActiveX control in a web page. Microsoft's ActiveX Control Pad can automatically generate code for inserting the CIMPLICITY SPC control and we recommend it. It is freely available from Microsoft's web site -- www.microsoft.com.

```
<HTML>
<HEAD>
<TITLE>New Page</TITLE>
</HEAD>
<BODY>

<OBJECT ID="Spc1" WIDTH=400 HEIGHT=300
 CLASSID="CLSID:8A843E25-2878-11D1-B6F5-00A02491B166">
    <PARAM NAME="_Version" VALUE="131079">
    <PARAM NAME="_ExtentX" VALUE="10583">
    <PARAM NAME="_ExtentY" VALUE="7938">
    <PARAM NAME="UpdateInterval" VALUE="00:00:10">
    <PARAM NAME="GroupName" VALUE="WIDGET">
    <PARAM NAME="Product" VALUE="LEFT HAND WIDGET">
    <PARAM NAME="QC" VALUE="WLength">
    <PARAM NAME="ProjectGroup" VALUE="\\SPC_DEMO\WIDGET">
</OBJECT>

</BODY>
```

Use of Netscape Navigator is not supported at this time.

Changing the Date/Time Format on Charts

SPC uses the short date style.

To change the date/time format of that style on a chart, use the Regional Settings option on your Windows Control Panel.

ActiveX Methods and Properties

SPC charting provides you with a wide range of built-in functionality. However, if you are familiar with ActiveX and want to add to that functionality as you design your screens, the following methods and properties are available.

void AboutBox( );	Calls the *About* dialog box.
Boolean GetControlLimits (ucl, cl, lcl, rucl, rcl, rlcl)	Gets the current control limits displayed on the chart
void Print( );	Calls the *Print* dialog box.
void UseAmbientProperties( );	Automatically changes an ActiveX control to use the ambient properties of the container

ActiveX Properties:

```
BSTR ChartTitle;
BSTR UpdateInterval;
short ChartType;
boolean ByTime;
BSTR StartTime;
BSTR EndDate;
BSTR EndTime;
short MaxDisplay;
boolean Exclusion mode;
OLE_COLOR BackgroundColor;
OLE_COLOR ChartColor;
OLE_COLOR ForegroundColor;
BSTR StartDate;
IFontDisp* TitleFont;
boolean UseAmbientBgColor;
boolean UseAmbientFgColor;
boolean UseAmbientChartTitleFont;
boolean UseAmbientChartColor;
BSTR BatchID;
BSTR ProjectGroup;
BSTR Product;
BSTR QC;
boolean ShowLegend;
boolean ShowChartTitle;
boolean ShowXAxisLabels;
boolean ShowXAxisTitle;
boolean ShowYAxisLabels;
boolean ShowYAxisTitle;
boolean UseAmbientAxisLabelFont;
boolean UseAmbientAxisTitleFont;
IFontDisp* AxisLabelFont;
IFontDisp* AxisTitleFont;
short ReportFields;
ISpcLineProperties* UCLLineProperties;
ISpcLineProperties* CLLineProperties;
ISpcLineProperties* LCLLineProperties;
ISpcLineProperties* ZoneLineProperties;
ISpcLineProperties* SpecLimitLineProperties;
ISpcLineProperties* NormalCurveLineProperties;
boolean ShowUpperControlLimit;
boolean ShowCenterLine;
boolean ShowLowerControlLimit;
boolean ShowZones;
boolean ShowSpecLimits;
boolean ShowNormalCurve;
boolean ShowInfoBox;
boolean ShowFixedNumberOfBars;
boolean ShowRemainingDefects;
boolean ShowValues;
MaxHistogramSamples;
NumberOfZones;
float UpperSpecLimit;
float LowerSpecLimit;
```

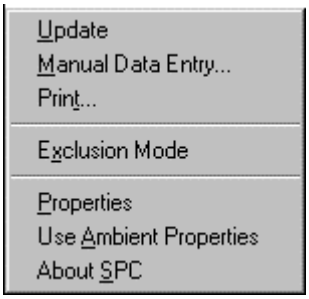
Using SPC Charts

Runtime Functions

You can perform several functions from within an SPC ActiveX control using options on the popup menu.

To perform runtime functions:

1. Display an SPC ActiveX control.
2. Position the cursor over the control and right-click.
3. Select an option from the popup menu—see figure.



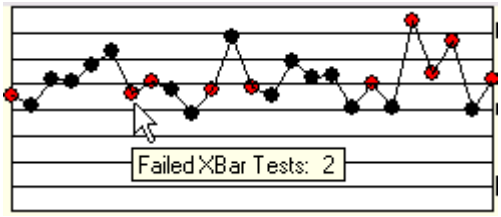
Popup Menu Option Descriptions:

- Update—updates the display with current data.
- Manual Data Entry—opens the Manual Data Entry dialog box for quality characteristics.
- Print—opens the Print dialog box for printing screen contents.
- Properties—opens the SPC Control Properties dialog box to set properties for the control.
- Use Ambient Properties—changes the foreground and a background color used by the ActiveX control to the ambient colors defined for the screen.
- About SPC—provides information about the SPC application, such as version number.

Displaying Test Results

You can perform up to eight (8) control tests on XBar-R and XBar-S data, and up to nine (9) control tests on the p, nP, c and u data. The results of these tests are displayed graphically on the appropriate chart. Points on the chart that meet one or more test criteria are highlighted with red asterisks (default). In addition, if you position the cursor over one of these points, a tool tip will display a summary of the results—see figure.

Example



Manual Data Entry

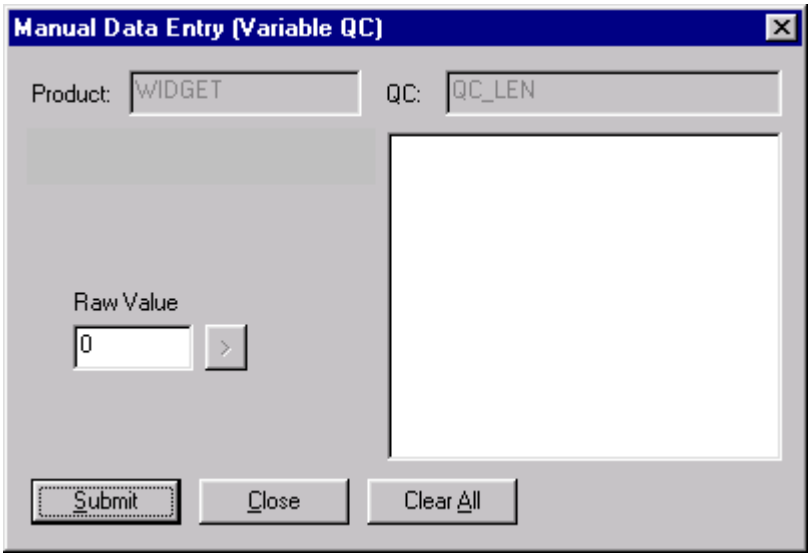
If Manual Data Entry was selected as a collection option when the Variable, Attribute or Defect QC was configured, you can use the Manual Data Entry popup menu option to input QC data for the chart.

Variable QC Data

When you select Manual Data Entry for a Variable QC chart, the Manual Data Entry (Variable QC) dialog box opens.

To manually enter data for a Variable QC chart:

1. In the Raw Value field, type the value to be manually entered.
2. Press > next to the input field to move the value into the list box.
3. Continue to enter manual data in the same manner.
4. Once all the manual data has been entered, click **Submit** to send the data to the SPC Data Collector.



Attribute QC Data

When you select Manual Data Entry for an Attribute QC chart, the Manual Data Entry (Attribute QC) dialog box opens.

To manually enter data for an Attribute QC chart:

- Click the appropriate radio button to establish the Subgroup Size as follows:

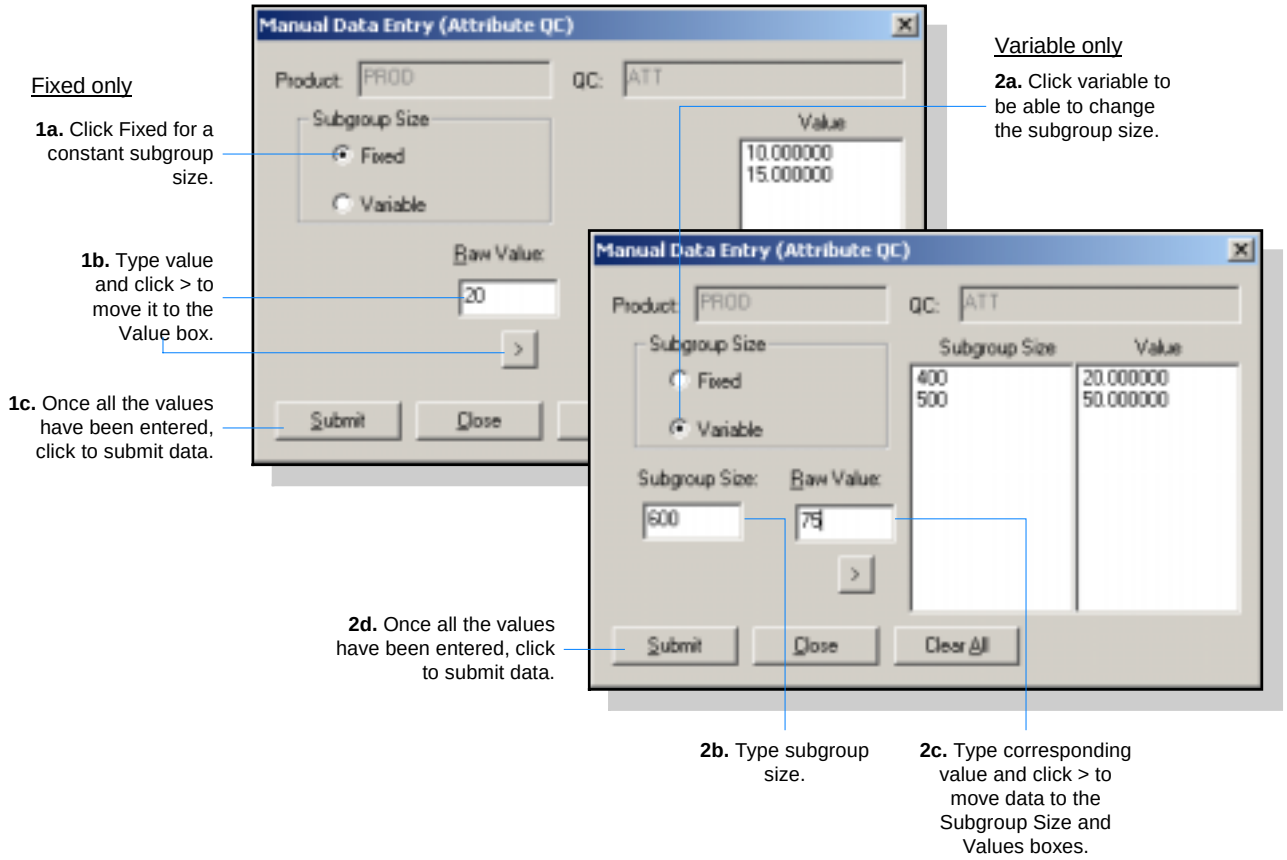
  Fixed—subgroup size is constant.

  Variable—subgroup size is subject to change.

Result: The input fields will reflect the selected option, Fixed or Variable—see figure.

Fixed

1. In the Raw Value field, type the value to be manually entered.
2. Press > to move the value into the Value box.
3. Continue to enter manual data in the same manner.
4. Once all the manual data has been entered, click **Submit** to send the data to the SPC Data Collector.



Variable

1. In the Subgroup Size field, type the value to be manually entered.
2. In the Raw Value field, type the value to be manually entered.
3. Press to move data into the Subgroup Size and Values boxes respectively.
4. Continue to enter manual data in the same manner.
5. Once all the manual data has been entered, click **Submit** to send the data to the SPC Data Collector.

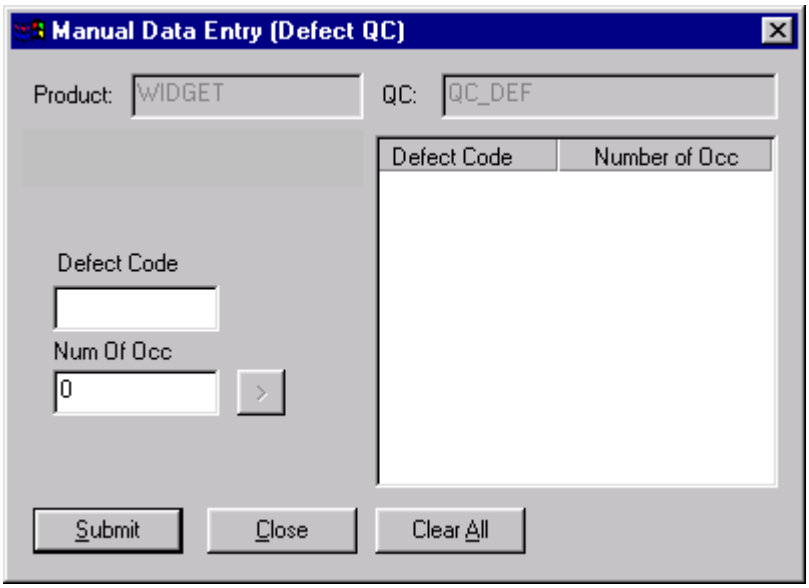
Tip: Use the **Clear All** button to quickly delete all of the data from the list box(es).

Defect QC Data

When you select Manual Data Entry for a Defect QC chart, the Manual Data Entry (Defect QC) dialog box opens.

To manually enter data for a Defect QC:

1. Type the Defect Category name in the Defect Code field.
2. Type the number of occurrences for the Defect Category in the Num of Occ field.
3. Press > next to the Num of Occ field to move the value into the list box.
4. Continue to enter manual data in the same manner.
5. Once all of the manual data has been entered, click **Submit** to send the data to the SPC Data Collector.



Appendix A - Tables of Constants for Control Charts

XBar and R Chart Factors for Control Limits

The values for samples ranging in size from 0 to 25 for XBar and R charts are:

	Chart for Averages	Chart for Ranges	
Sample Size	A_2	D_3	D_4
0	0.000	0.000	0.000
1	2.660	0.000	3.267
2	1.881	0.000	3.268
3	1.023	0.000	2.574
4	0.729	0.000	2.282
5	0.577	0.000	2.114
6	0.483	0.000	2.004
7	0.419	0.076	1.924
8	0.373	0.136	1.864
9	0.337	0.184	1.816
10	0.308	0.223	1.777
11	0.285	0.259	1.755
12	0.266	0.284	1.717
13	0.249	0.308	1.692
14	0.235	0.329	1.671
15	0.223	0.348	1.652
16	0.212	0.363	1.637
17	0.203	0.378	1.622
18	0.194	0.391	1.608
19	0.187	0.403	1.597
20	0.180	0.415	1.585
21	0.173	0.425	1.575
22	0.167	0.434	1.566
23	0.162	0.443	1.557
24	0.157	0.451	1.548
25	0.153	0.459	1.541

XBar and S Chart Factors for Control Limits

The values for samples ranging in size from 0 to 25 for XBar and S charts are:

Chart for Averages		for Standard Deviations	
Sample Size	**A_3**	**B_3**	**B_4**
0		0.000	
1		0.000	
2	2.659	0.000	3.268
3	1.954	0.000	2.568
4	1.628	0.000	2.266
5	1.427	0.000	2.089
6	1.287	0.030	1.970
7	1.182	0.118	1.882
8	1.099	0.185	1.815
9	1.032	0.239	1.761
10	0.975	0.284	1.726
11	0.927	0.321	1.679
12	0.886	0.354	1.646
13	0.850	0.382	1.618
14	0.817	0.406	1.594
15	0.789	0.428	1.572
16	0.763	0.448	1.552
17	0.739	0.466	1.534
18	0.718	0.482	1.518
19	0.698	0.497	1.503
20	0.680	0.510	1.490
21	0.663	0.523	1.477
22	0.647	0.534	1.466
23	0.633	0.545	1.455
24	0.619	0.555	1.445
25	0.606	0.565	1.435

Appendix B - X-Individual Chart Calculations

X-Individual Chart Calculations

The X-Individual chart is sometimes called a pre-control chart. This type of chart is used to determine the stability of the center of the process. The control limits are calculated by determining the standard deviation of the sample population.

X-Individual Center Line

For the X-Individual chart, the center line is calculated as:

$$\overline{X} = \frac{x_1 + x_2 + \ldots + x_n}{n}$$

where x_1 through x_n are the values of each item in the set and n is the number of samples.

X-Individual Standard Deviation

The standard deviation is calculated as:

$$S = \sqrt{\frac{\sum_{i=1}^{n} \left(x_i - \overline{x}\right)^2}{n-1}}$$

The formulas used for calculating the upper and lower control limits are:

$$UCL = \overline{X} + 3S \qquad LCL = \overline{X} - 3S$$

Appendix C - XBar-R Chart Calculations

XBar-R Chart Calculations.

The XBar-R chart displays two charts, one for the Xbar values and the other for the Range values. The formulas for calculating the center lines and control limits for the XBar-R control chart are detailed in the following sections.

XBar-R Chart Center Line

Based on the sample size, the mean for a given sample can be calculated as:

$$\overline{X} = \frac{x_1 + x_2 + \ldots + x_n}{n}$$

where x_1 through x_n are the values of each observation in the sample and n is the number of observations in the sample.

Because an XBar-R chart displays the average of each sample in the set, its center line is calculated as:

$$\overline{\overline{X}} = \frac{\overline{X}_1 + \overline{X}_2 + \ldots + \overline{X}_m}{m}$$

where $\overline{X}_1$ through $\overline{X}_m$ are the averages of each sample, and m is the number of samples. This grand average becomes the center line of the XBar chart.

XBar-R Chart Control Limits

To construct the upper control limit (UCL) and lower control limit (LCL) for the XBar-R chart, we need to know the standard deviation of the data. This can be estimated with the range method.

In a sample of size n, the range is the difference between the smallest and largest observations. In other words:

$$R = x_{\max} - x_{\min}$$

If R_1 through R_m is the range of m samples, then the average range is:

$$\overline{R} = \frac{R_1 + R_2 + \ldots + R_m}{m}$$

The formulas used for calculating the upper and lower control limits for the XBar chart are:

$$UCL = \overline{\overline{x}} + A_2 \overline{R} \qquad LCL = \overline{\overline{x}} + A_2 \overline{R}$$

Where A_2 is a tabulated value based on the sample size. See the *XBar Chart Factors for Control Limits* table in Appendix A for values of A_2 for sample sizes ranging from 1 to 25.

If the sample size is greater than 25, the formulas are:

$$UCL = \overline{X} + 3S \qquad LCL = \overline{X} - 3S$$

where S is the standard deviation for the chart.

R Chart Center Line

For the R chart, the formula for calculating the center line is:

$$\overline{R} = \frac{R_1 + R_2 + \ldots + R_m}{m}$$

R Chart Control Limits

The formulas used for calculating the upper and lower control limits for the R chart are:

$$UCL = \overline{R} D_4 \qquad LCL = \overline{R} D_3$$

where D_4 and D_3 are tabulated values based on the sample size. See the *Range Chart Factors for Control Limits* table in Appendix A for values of D_3 and D_4 for sample sizes ranging from 1 to 25.

If the sample size is greater than 25, the formulas are:

$$UCL = \overline{R} + 3S \qquad LCL = \overline{R} - 3S$$

where S is the standard deviation for the chart.

Appendix D - XBar-S Chart Calculations

XBar-S Chart Calculations

The XBar-S chart displays two charts, one for the Xbar values and the other for the Sigma values. The formulas for calculating the center lines and control limits for the XBar-S control chart are detailed in the following sections.

XBar-S Chart Center Line

Based on the sample size, the mean for a given sample can be calculated as:

$$\overline{X} = \frac{x_1 + x_2 + \ldots + x_n}{n}$$

where x_1 through x_n are the values of each observation in the sample and n is the number of observations in the sample.

Because an XBar-S chart displays the average of each sample in the set, its center line is calculated as:

$$\overline{\overline{X}} = \frac{\overline{X}_1 + \overline{X}_2 + \ldots + \overline{X}_m}{m}$$

where $\overline{X}_1$ through $\overline{X}_m$ are the averages of each sample, and m is the number of samples. This grand average becomes the center line of the XBar chart.

XBar-S Chart Control Limits

To construct the upper control limit (UCL) and lower control limit (LCL) for the XBar-S chart, we need to know the standard deviation of the data.

In a sample of size *n*, the standard deviation is:

$$s = \sqrt{\frac{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2}{n-1}}$$

If s_1 through s_m is the range of m standard deviations, then the average standard deviation is:

$$\bar{s} = \frac{s_1 + s_2 + \ldots + s_m}{m}$$

The formulas used for calculating the upper and lower control limits for the XBar chart are:

$$UCL = \bar{\bar{x}} + A_3\bar{s} \qquad LCL = \bar{\bar{x}} - A_3\bar{s}$$

Where A_3 is a tabulated value based on the sample size. See the *XBar Chart Factors for Control Limits* table in Appendix A for values of A_3 for sample sizes ranging from 1 to 25.

If the sample size is greater than 25, the formulas are:

$$UCL = \overline{X} + 3S \qquad LCL = \overline{X} - 3S$$

where S is the standard deviation for the chart.

S Chart Center Line

For the S chart, the formula for calculating the center line is:

$$\bar{s} = \frac{s_1 + s_2 \ldots + s_m}{m}$$

S Chart Control Limits

The formulas used for calculating the upper and lower control limits for the S chart are:

$$UCL = \bar{s}B_4 \qquad LCL = \bar{s}B_3$$

where B_3 and B_4 are tabulated values based on the sample size. See the *Range Chart Factors for Control Limits* table in Appendix A for values of B_3 and B_4 for sample sizes ranging from 1 to 25.

If the sample size is greater than 25, the formulas are:

$$UCL = \bar{s} + 3S \qquad LCL = \bar{s} - 3S$$

where S is the standard deviation for the chart.

Appendix E - Histogram Chart Calculations

Histogram Chart Calculations

The Histogram shows you the distribution, the central tendancy and the scatter or variability of the sample data. This chart also displays the calculated process capability for the data.

There are two process capability measurements displayed by this chart, C_p and C_{pk}. Depending on whether the source of the data is an XBar-R or XBar-S chart, the estimate of the process standard deviation differs.

For XBar-R data, the estimate of the process standard deviation is:

$$\hat{\sigma} = \overline{R} / d_2 = \hat{\sigma}_{\overline{R}/d_2}$$

For XBar-S data, the estimate of the process standard deviation is:

$$\hat{\sigma} = S / c_4 = \hat{\sigma}_{\overline{S}/c_4}$$

Capability Index

C_p is the capability index defined as the tolerance width divided by the process capability, irrespective of process centering.

For XBar-R data, it is calculated as:

$$\frac{USL - LSL}{6\hat{\sigma}_{\overline{R}/d_2}}$$

For XBar-S data, it is calculated as:

$$\frac{USL - LSL}{6\hat{\sigma}_{\overline{S}/c_4}}$$

Capability Index for Process Centering

C_{pk} is the capability index which accounts for process centering and is defined as the minimum of the upper and lower capability indexes. It relates the scaled distance between the process mean and the closes specification limit to half the total process spread.

For XBar-R data, the upper and lower indexes are calculated as:

$$CPU = \frac{USL - \overline{\overline{X}}}{3\hat{\sigma}_{\overline{R}/d_2}} \text{ and } CPL = \frac{\overline{\overline{X}} - LSL}{3\hat{\sigma}_{\overline{R}/d_2}}$$

For XBar-S data, the upper and lower indexes are calculated as:

$$CPU = \frac{USL - \overline{\overline{X}}}{3\hat{\sigma}_{\overline{S}/c_4}} \text{ and } CPL = \frac{\overline{\overline{X}} - LSL}{3\hat{\sigma}_{\overline{S}/c_4}}$$

Appendix F - P Chart Calculations

P Chart Calculations

The P chart measures the proportion of nonconforming (discrepant or defective) items in a group of items being inspected. Proportion is defined as the ratio of the number of nonconforming items in a population to the total number of items in that population. Sample sizes need not be equal.

Data Available

N = Number of units produced in each sample (subgroup size)

R(1..K) = Number of units rejected in each subgroup

K= Inspection Quantity

To be calculated

Average Proportion Non conforming,

$$\overline{p} = \frac{\sum_{i=1}^{k} R_i}{\sum_{i=1}^{k} N_i}$$

Sigma (standard deviation)

$$\mathbf{SP} = \frac{\sqrt{(\overline{p}(1-\overline{p}))}}{N}$$

Center Line and Control Limits

The control limits are the process average plus or minus an allowance for the variation that could be expected if the process where in statistical control, given the subgroup size. For the study period of k subgroups, calculate the upper & lower control limits:

Center Line (CLP): $\bar{p}$

Upper Control Limit (UCLP): CLP + 3 SP

Lower Control Limit (LCLP): MAX(0,(CLP – 3 SP))

Appendix G - nP Chart Calculations

nP Chart Calculations

The nP chart measures the number of nonconforming items in an inspection lot. It is identical to P chart except that the actual number of nonconforming items, rather than their proportion of the sample, is plotted. The inspection sample sizes must be equal in this case.

Data Available

N = Number of units produced in each sample (subgroup size)

R(1..K) = Number of units rejected in each subgroup

K = Inspection Quantity

To be calculated :

Process Average Number Non conforming,

$$\overline{p} = \frac{\sum_{i=1}^{k} R_i}{\sum_{i=1}^{k} N_i}$$

Sigma (Standard deviation)

SNP = $\sqrt{(N\,\overline{p}(1-\overline{p}))}$

Center Line and Control Limits

Calculate the Control limits :

Center Line (CLNP) : N $\overline{p}$

Upper Control Limit (UCLNP) : CLNP + 3 SNP

Lower Control Limit (LCLNP) : MAX(0,(CLNP – 3 SNP))

Appendix H - C Chart Calculations

C Chart Calculations

The C chart measures the number of non-conformities (discrepancies or defects) in an inspection lot.The C chart requires a constant sample size.

Data Available

N = 1

R(1..K) = Number of defects in each subgroup

K = Inspection Quantity

To be calculated :

Process Average Number Non conformities,

$$\bar{c} = \frac{\sum_{i=1}^{k} R_i}{k}$$

Sigma

SC = $\sqrt{\bar{c}}$

Center Line and Control Limits

Calculate the Control limits

Center Line (CLC)	:	$\bar{c}$
Upper Control Limit (UCLC)	:	CLC + 3 SC
Lower Control Limit (LCLC)	:	MAX(0,(CLC – 3 SC))

Appendix I - U Chart Calculations

U Chart Calculations

The U chart measures the number of non-conformities per inspection unit in subgroups, which can have varying sample sizes. It is similar to C chart except that the number of non-conformities is expressed on a per unit basis.

Data Available

N = Subgroup size

T(1..K) = Total produced

K = Inspection Quantity

D(1..K) = Total Defects in sample

To be calculated :

Process Average Non conformities Per Unit,

$$\bar{u} = \frac{\sum_{i=1}^{k} U_i}{K} \qquad U(1..K) \text{ where } U_I = D_I / T_I$$

Sigma (Standard deviation)

$$SU = \frac{\sqrt{\bar{U}}}{N}$$

Center Line and Control Limits

Calculate the Control limits :

Center Line (CLU)	:	$\bar{u}$
Upper Control Limit (UCLU)	:	CLU + 3 SU
Lower Control Limit (LCLU)	:	MAX(0,(CLU – 3 SU))

Appendix J – Upgrading Quality Charts to Enhanced SPC Charts

Upgrade Quality Charts to Enhanced SPC Charts

You must upgrade your existing Quality Charts if one of the two items listed below is true:

- Charts were created using a version of CIMPLICITY HMI *prior* to v3.1
- Charts were created using CIMPLICITY HMI v3.1, but you did *not* purchase and install the Enhanced SPC software (IC646NSP000A) prior to creating the charts

If you are currently using CIMPLICITY HMI v3.2 or later, and you attempt to display a screen containing one of these charts, you will see a message indicating that the charts must upgraded.

Before beginning the upgrade, make sure you:

- back up all necessary CIMPLICITY HMI projects, as the upgrade procedure will alter both your screens and your project.
- verify that an SPC ODBC data source exists. *See "Creating the SPC Data Soiurce" for additional information.*

Starting the Upgrade Procedure

To start the upgrade procedure:

1 From your Windows desktop, press Start.

2. Select Programs>CIMPLICITY>HMI>Workbench to open the Workbench window.
3. Click File on the menu bar.
4. Select Open to display the Open window.
5. Navigate to your SPC project.
6. Double-click on the project icon in the window to display it in the Workbench.
7. Click Tools on the menu bar.
8. Select Upgrade Old SPC Charts.
9. Follows the prompts to upgrade the charts.

Tip: To open a project quickly in the Workbench, create a shortcut on your Windows desktop.

What Happens during the Upgrade Procedure?

When you upgrade your old SPC charts to the latest version of the software, you will be prompted for information in order to facilitate the transition. The following list explains what happens during the upgrade procedure.

The upgrade procedure begins by prompting you for an ODBC data source for storing the results of intermediate SPC calculations. The ODBC data source is where the SPC data collector process will store its data.

After prompting for an ODBC data source, the upgrade procedure searches through all CimView screens, starting in the directory you specify, and recursing through all its subdirectories. As the utility finds references to old style Quality Charts in these screens, it prompts you for a Product Name and QC Name for each of the charts. Then it replaces the charts.

Finally, the upgrade procedure generates a single SPC configuration file called **`SPC1.SPC`**. It places this configuration file in your project's **`SPC`** directory. All charts in the project need to know the location of this configuration file. The upgrade procedure takes care of this for existing charts that it upgrades.

Caution: Do not move, rename, or delete the SPC1.SPC file.

When you add a new chart you will need to select the **`SPC1.SPC`** file as the group file in the chart's *General* property page. The configuration file tells chart what quality characteristics are available and where to find the data. The data collection process also uses this configuration file to know what data to collect, and on which data source to log results.

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